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EDUCATION AND ENVIRONMENT

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In a true sense education may be defined as the process of systematically training the individual to adjust himself to his environment in all its aspects.

This "adjustment to environment" through education is, of course, not a new idea. It runs through educational literature certainly since the days of Herbert Spencer. But the term has been used in a restricted sense in reference to the scientific elements in education: the natural sciences and mathematics as assisting man to understand his physical environment, to accommodate himself to its laws, and to gain mastery over it for his own benefit.

The "Arts" so-called:—language, literature, history and philosophy and religion, were under this conception set apart as something different, and possibly loftier in the role they were expected to play in education. They were at once the carriers as well as the very essence of the great tradition, the human heritage that we call culture.

And when what we now call the "Social Sciences" captured the interest of educators, they were looked upon more or less askance and were assigned to a third category not quite scientific and certainly, oh certainly something less than cultural. And so in our educational philosophy there seems to be a trichotomy: "science," the "arts," and "social sciences," each in a special category, each with a function of its own, and each perhaps claiming priority at various stages in the development of our educational theory and practice.

Our position as educators and classroom teachers is made much stronger, our effectiveness is increased, and our influence upon our students greatly enhanced if we hold to the functional unity of knowledge as it operates in the educational process. For knowledge is not identical with education in any modern sense.

What does such a concept mean, not only in the work of all teachers, including of course, teachers of mathematics and science, but also in the education of the teacher?

Our environment is the setting in which we must live our lives and do our work. This setting has in it a multitude of elements, all of which impinge directly upon us and to which we are compelled to make some response and adopt some attitude. To the degree to which we respond and adjust ourselves to them, life is normal, successful, happy, and rich. If we fail to respond and adjust, life fails in one way or another.

A universal element of the human environment is the physical one. We live in space and time, surrounded by a vastly complex world of nature over whose normal course we can exercise only a limited control. This physical world has its own laws which we must be educated in one way or another to know and to accept if we are to survive at all. This is the area in which mathematics and the natural sciences constitute the instrument that education must employ if it is to function here at all.

That this is a constantly widening area, no one can question. Not only is this physical side of our environment identical with what primitive man had to face, but it has been made vastly more complex and has developed an infinite variety of man's own mechanical inventions and their unexpected by-products. Each of these, while giving man some new advantage, at the same time also increases the dangers to his survival if he remains ignorant of them. The slow-moving, gigantic dinosaur, the swift lion, are replaced by the ten-ton truck and the speeding roadster and airplane! Flood, wind, and lightning of the primitive environment are only occasional incidents today compared with the daily perils presented by high voltage-electricity or the ignorant use of drugs and chemicals.

So the knowledge of nature and her laws, both in their qualitative and their quantitative aspects is an essential part of education. Now, since the earliest dawn of human life another element in our environment has been developing. As soon as man experienced life he began to record it and felt impelled

to share his experience and to transmit it to his offspring. Language, literature, history, the later generalizations of philosophy, and the sense of dependence upon a guiding reason in the universe as expressed in religion, these represent means in man's efforts to understand life and nature and to adjust himself to his world. They became, as a tradition transmitted through the ages, an actual part of man's environment. As he fails to grasp this, to make it serve him, to wield it as part of his equipment for living and for giving meaning to life, he *fails* to *live*. To this heritage he must adjust himself quite as much as to any other part of the setting in which his life must be spent. To this heritage, too, he adds his generation's contribution and the heritage increases through the ages.

The third element in man's environment is the most complex of all. It is humanity itself. Human relations have always offered difficult problems of adjustment. These are the more perplexing today because in the first place the unit of the family, of the clan, of the tribe, has been expanded into the city, the state, the nation, and in the second place the increase of population has brought density and lack of "elbow room." Unless this is recognized as an inherent part of our environment, adjustment to the other elements will prove in vain.

This area is the one in which the social sciences come into play and must be depended on to give light and leading, just as do the natural sciences and mathematics in relation on the physical side. Unless these newer sciences do play their part in pointing the way to our adjustment to the social environment, then order and justice, security, peace and freedom will remain unattainable.

Now, these three elements of our environment are not separable but constitute a unit. They interlock and interweave, forming together the setting in which the individual personality must find its place if it is to survive and grow into its promise of a divine manhood. For this growth in all of its phases education is intended, and to this it must contribute.

This necessarily brings us to those who are the educators and to their preparation. Modern specialization, necessary as it is in the development of modern life, has brought with it the great disadvantage that the specializing student fails to see knowledge as a whole and as a functional unity. His own narrower interests fill his view, and when he turns to teach the young he approaches his task from the angle of his own special field of

interest. His own subject becomes the all important thing, instead of being part of a great mosaic in which all the shapes and sizes and colors must blend to make an intelligible and beautiful design.

In our elementary and high schools and in the early years at least of college, the schools and teachers must emphasize the approach implied in what has been pointed out with respect to the unity of the world in which we live, the totality of our environment. In order to be able to do this the teacher must himself have had the opportunity through his own education to grow into a personality to which no part of his total environment is utterly strange. If he is to do an adequate task, all the skills in which he has been trained will be directed to contribute to the adjustment of his students to our single world in all its phases. To do this, obviously he must be broadly educated in the sciences, the arts, and the social sciences. He dare not let anything human be foreign to his interests.

We teach not only by book and laboratory and speech, but even more by example. Character and ideals are "caught" in that way more than in any other. Does this mean that we teachers are consigned to the awful fate of being paragons for youth to copy? The answer is very simple: we fall so far short of perfection that no efforts of ours to achieve it can possibly overshoot the mark.

SIGHT-SAVING CLASSES

The National Society for the Prevention of Blindness has announced that it is cooperating with the following colleges and universities in offering, at their 1940 summer sessions, courses for the preparation of teachers and supervisors of sight-saving classes:

Oregon State System of Higher Education, Portland, Oregon. (Elementary course.) June 17th to July 26th. Director of the course: Miss Olive S. Peck, Supervisor of Sight-Saving, Cleveland Public Schools, Cleveland Ohio.

Wayne University, Detroit, Michigan. (Elementary course.) June 24th to August 2nd or July 1st to August 9th. Director of the course: Miss Margaret M. Soares, Supervisor of Braille and Sight-Saving Classes, Detroit, Michigan.

State Teachers College, Buffalo, New York. (Elementary course.) July 1st to August 9th. Director of the course: Miss Matie M. Carter, Associate Supervisor, Physically Handicapped Children's Bureau, State Education Department, Albany, New York.

University of Minnesota, Minneapolis, Minnesota. (Advanced course.) June 17th to July 26th. Director of the course: Mrs. Winifred Hathaway, Associate Director, National Society for the Prevention of Blindness, 50 West 50th Street, New York, N. Y.

BASE EIGHT ARITHMETIC AND MONEY

E. M. TINGLEY
Oak Park, Illinois

What this is about: Eight is the best base for our arithmetic, not ten or twelve.

Numbers and arithmetic are for real material things which include money, weights and measures.

Our minds prefer halves, the even divisions of things. Material things divided into fifths as in the metric system and in thirds and fifths in moneys are difficult for our minds.

Psychologists and not calculators, teachers, arithmeticians, physicists, or legislators must decide what is the best base for our arithmetic.

Psychologists have entirely neglected the arithmetic bases but they must find that eight furnishes the best "all-around" mental handle for the preferred fractions, halves and halves of halves repeated indefinitely.

Practical arithmetic: The practical use of numbers and arithmetic begins with real things and terminates in real things. Things and their fractions existed before numbers and they will continue after base ten is discontinued.

We represent things and their fractions by numbers, calculate by arithmetic and return the resulting numbers into real things.

Abstract numbers and arithmetic detached from things become only an empty game, as is chess, and of little practical value except as a mental exerciser. Witness the theory of numbers.

We are here interested only in the contact of our minds at the origin of a number with a thing and likewise with the final discharge or return of a number into a thing, not in the intermediate arithmetical operations.

It is at the beginning and end of numbers with fractions of things, not with integers, that improved mental efficiency is to be obtained with base eight.

Inventions of our minds are numbers and arithmetic, mental tools, enormously extended in power through the idea of fractions and the decimal form of writing fractions. The decimal writing form may be used with any base.

Not having the decimal form the ancients employed the clumsy device of base sixty by which fractional parts were

written as integers. Base sixty is still with us in time and angular measures.

As tenths of things are not acceptable to our minds the metric system measures guns and houses in integral millimeters. The decimal and the metric systems lack the easy use of halves, quarters, and eighths over the entire range of measurements.

The idea of numbering things is a mental tool devised by the mind for the assistance of the mind. It follows that the stage at which assistance begins is obscure. Does it begin with the idea of two things or half of a thing or with a larger group that may be matched or numbered at a glance.

We accept the seven-day week as a measure of time as it is within our comprehension unaided by numbers. We can recall events in three days just past or plan for the next three days to come. We would not tolerate irregularly mixed weeks of both six and seven days.

We have endured the 28 to 31-day months as these groups are beyond our unaided comprehension. Yet the variable months as time measures are just as reasonable as variable weeks. All months should contain four weeks so that the industrial year may be divided evenly into halves and quarters.

Numbers without things: For numbers only, abstract numbers that are not associated with things, any arithmetic base may be used. Even a prime base has been proposed. Any odd base as five, seven or eleven seems instinctively objectionable. Numbers alone do not determine the best arithmetic base.

Base eight arithmetic is for the every-day non-mathematical users of small mental problems and small numbers. However, base eight has also easy and simple relations with bases two and four, thereby making possible many beautiful and powerful properties of numbers now impractical with bases ten or twelve.

Four operations in arithmetic: In general integers remain integers in the addition, subtraction, and multiplication of things and numbers. Here any base may be used.

Addition and subtraction are not nearly so powerful mental tools as are multiplication and division. Division gives us the fractions of things and of numbers.

Division, the descending scale operation, is equally as powerful a mental tool as is multiplication. There is no difference between multiplication and division except that of direction. Division and multiplication of things and of numbers should be used with equal facility.

Our preferred descending scale of repeated halves of things should be as easily and freely used and written as repeated doubles.

We like halves of things because we ourselves are closely related to halves through our symmetrical bodies, our two hands and two eyes, by which we perceive things.

The simplest idea of a fraction is one-half of a thing. Halves of a thing give a child his first idea of fractions but later he must calculate about halves with fifths concealed in decimals, hence a difficulty with fractions.

Children using base eight in the future will count; four, eight, eight and four, two eights, two eights four, etc. (and write correspondingly, 4, 10, 14, 20, 24) and never know our present five, ten, fifteen, twenty counting. They will write the half $\frac{1}{2}$ or 0.4, the quarter as $\frac{1}{4}$ or 0.2, and the eighth 1/10 or 0.1.

Halves, a couplet, are the most easily comprehended of the fractions because of their simplicity, symmetry or evenness, and fewness. There are only two halves of a thing but there are three thirds and five fifths. Quarters are only halves of halves. The larger the number of equal fractional parts the more difficult is the construction mechanically and the more difficult the comprehension of the thing group.

We like to think of halves in our native mind language but we must now write halves in the foreign language of fifths and tenths of the decimal and the metric systems. Halves of things and our number system should run parallel with the natural or constitutional preferences of our minds.

Fractions of things and division are not now so easily or so extensively used as are the multiples largely because base ten leads to fifths of things which are not so acceptable to our minds as are halves and quarters.

Division of numbers by ten in the decimal notation is of course easy. But tenths give us fifths and who divides a thing into fifths if it can possibly be avoided? The fifths of money and of metric scales are to fit the decimal base, not our minds. They are provided for us, not by us.

We are now denied the best use of halves, our preferred fractions of things, half of our powerful number tools by the use of ten as a base.

As a summary we find that the preferred even fractions and division decide that eight is the best base for our arithmetic.

Base twelve: This is the favorite of arithmeticians and calcu-

lators, those who do not measure things. It is favored in theory because of the number of different ways twelve may be divided, especially into thirds. But twelve contains the prime factor three, as objectionable as the prime fifths of decimals. Thirds we now have but they are not used. Who divides a year or the moon phases into thirds? We always speak of one-third of an hour as twenty minutes. The foot is one-third of a yard but yards are popularly divided into halves, quarters, and eighths. The English would not use the four-pence coin so it was retired and the three-pence substituted, one-fourth of a shilling. Tabulate the good and used thirds of things and note how few they are compared with the binary divisions of things. Why spoil all good halves by associating them, as they must be, with poor thirds of base twelve or the fifths of base ten? Number thirds may be handled as easily with base eight as they now are with base ten.

Money: Our U. S. money is an application of the decimal and the metric principle. However inspection shows that fifths are here avoided and halves are favored. The accompanying tabulation of the ratios in the coinages of the world shows the same tendency.

The use of halves extends to our stock and bond quotations and foreign exchange resulting in troublesome calculations in base ten.

Too many regard money steps as additional only, that is, five cents plus five cents is ten cents. Accordingly the next step would be fifteen cents. Such is not the case. Money steps or scales proceed up and down by ratios, mixed and difficult ratios now, and not by addition or subtraction.

Some may contend that it is not necessary to change our arithmetic to base eight to accommodate simple mental calculations about money and other measures. But money and measures are very long range devices extending to billions and acceptable ratios must be used to handle these ranges easily. Unfortunately various different ratios are now used to accommodate money and other measures to base ten in place of the easy and exclusive halves and doubles that would be used with base eight.

Money tabulations: This is prepared from reliable data used before the gold standards were abandoned. It is limited to coins and their ratios, or the different money systems are stripped to their bones; ratios only. Relative values between the different

countries or exchange values are not indicated. What a sorry mixture is presented. What a relic of custom and tradition rather than the result of reason and mind engineering by psychologists.

MONEYS OF THE WORLD

Ascending Ratios between Coin Values

United States	5	2	5/2	2	2	5/2	2	2	2				
Canada	5	2	5/2	2	2	5	5	2					
France	2	5/2	2	5/2	2	2	2	5/2	2	2	5		
Scandinavia	2	5/2	2	5/2	2	2	2	5/2	2	2			
Netherlands	2	5/2	2	2	5/2	4	5/2	2	2				
Belgium	2	5/2	2	5/2	2	2	2	5/2	2	2			
Switzerland	2	5/2	2	2	5/2	2	2	5/2	2	2	5		
Italy	2	2	5/2	2	2	5/2	2	2	5/2	2			
Spain	2	5/2	2	2	2	5/2	2	2	4/5	4			
Austria	2	5/2	2	5	2	2	25/2	4					
Czech	2	2	5/2	2	5	2							
Finland	2	5/2	2	2	5	2	10	2					
Greece	2	5/2	2	2	5/2	2	2						
Hungary	2	5	2	5/2	2	2	5/2	2	2				
Turkey	2	2	2	2	5/4	2	2	2	5/4	2	2	5/2	2
Argentina	2	5/2	2	2	25/2	2							
Brazil	2	2	5/4	2	2								
Mexico	2	5/2	2	2	5/2	2	5	2	2	5/2			
Cuba	2	5/2	2	2	2	5/2	2	2	5/4	2	2		
Venezuela	5/2	2	2	2	2	5/2	2	2	5				
Uruguay	2	5/2	2	2	5/2	2							
Chile	2	2	5	2	5/2	4	5/2	2					
Algeria	2	5/2	2	5/2	2	2	2	5	2	5			
Japan	2	2	5/2	2	2	5/2	10	2	2				
Great Britain	2	2	3	2	2	2	5/4	4	2				
Germany	2	5/2	2	5	2	2	3/2	5/3	2	2			
Russia	2	3/2	5/3	2	3/2	4/3	5/2	2	10				
Australia	2	3	2	2	10	2							
India	3/2	2	8	2	2	2	15						
Base Eight	2	2	2	2	2	2	2	2	2	2	2	2	2

Construction of the table: Our familiar U. S. coins illustrate the ratio principle. The ascending ratios are used in order to make the tabular printing simpler and also to start each series always with the lowest coin value. For descending ratios use the reciprocal of the ascending scale ratios.

Values of coins in cents are in the upper line, ratios between coin values are in the lower line.

1 5 10 25 50 100 250 500 1000 2000

5 2 5/2 2 2 5/2 2 2 2

Here two is the favored ratio. Five is too large a step so five halves are used to evenly split the step and tie to base ten. Five halves is an awkward ratio.

The possible simplicity of base eight money is shown in the last line of the table.

Our two-dollar bill is unpopular only because it has no double; there is not yet a four-dollar bill.

Tables of ratios between the units of the various English weights and measures may also be constructed in the same manner as the money ratios.

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NEW PAINTS REFLECT ULTRAVIOLET LIGHT

The advent of low-cost "health" lamps emitting ultraviolet light rays has spurred paint manufacturers to develop paint for walls of rooms which will reflect a large amount of these beneficial radiations. Ordinary paint usually reflects less than 10 per cent of the ultraviolet light which falls on it so that the walls of the ordinary room are merely "traps" for the ultraviolet light which comes from the new lamps. D. F. Wilcock, working on the Basic Science Laboratory of the University of Cincinnati, has developed white interior finishes which now reflect up to 72 per cent of the ultraviolet light, making it possible to have indirect health ray light for a room.

SUMMER MEETING OF THE N.C.T.M.

The National Council of Teachers of Mathematics will hold its 1940 summer meeting on July 1, 2, and 3 in Milwaukee, Wisconsin. The headquarters will be the Hotel Pfister. The theme of the meetings is: How MATHEMATICS SERVES OUR COMMUNITY. Questions and suggestions should be addressed to A. E. Katra, 525 West 120th Street, New York, N. Y.

There will be no admission charge to the meetings.

INITIATION CEREMONY FOR A SCIENCE CLUB

TEMPLE C. PATTON
Worcester Academy, Worcester, Mass.

The following informal initiation ceremony has been used by the Science Club at Worcester Academy for several years. It is reproduced here in the hope that possibly other science clubs, lacking an initiation ceremony, may find it useful in working out their own ritual.

Three people are called for in carrying out the ceremony: a Grand Master of Ceremonies, a Most High Alchemist, an Assistant Alchemist.

Preferably the initiation should be carried out in a darkened room large enough to seat the entire club. Front-row seats should be reserved for the initiates. Members of the society not taking part in the performances should be seated behind the initiates. Lighting should be chiefly from lights focused on the faces of the initiates. Candle light may be used for illuminating the script reading matter. The Grand Master of Ceremonies should take his place behind a table facing the initiates during the initiation ceremony. The Most High Alchemist and his assistant should be seated at one side. Properties for the initiation should be also off to this side. Costuming and incidental lighting may be made as elaborate as desired.

It has been the experience of the club at Worcester Academy that seriousness and silence on the part of the members of the club during the reading of the script produces a more profound effect on the initiates than frequent interruptions of the script reading by laughter or random "wise-cracks." It will probably be necessary at times for the Grand Master of Ceremonies to ad lib during the initiation to cover unexpected situations or to facilitate the administering of the ordeals.

At the start of the ceremony, members of the society should be in their places. Initiates, who have been waiting outside the room, should then be ushered in by the Assistant Alchemist and seated in the front row of seats reserved for them. Some order of knocks and counter-knocks at the door may be arranged between the Most High Alchemist (inside) and Assistant Alchemist (outside) before admittance of initiates to room is permitted. The ritual should then proceed.

(*The G.M.C. raps with a gavel four times. He then addresses the members of the society in a slow and dignified voice.*)

G.M.C.—Fellow members of (*name of club*), we are gathered here at this time in most solemn high session to test and pass upon the qualifications of certain rank outsiders who have deigned to approach our august body and beg admittance to our organization. They know not what they ask.

Here they appear before us,—weak, sniveling wretches. How can their poor powers possibly hope to surmount the awful and appalling ordeals which lie before them in the next hour? But they say they are prepared,—poor souls. So be it.

Exalted members of (*name of club*), is it your wish that we proceed with the inquisition?

Members of Club—Yea, Grand Master.

G.M.C.—Then I command the four ordeals be prepared and may these miserable creatures be granted strength to withstand their rigors.—Initiates, arise! (Initiates line up in a row facing the Grand Master of Ceremonies)—Listen carefully to the first ordeal which you must undergo if you would gain admittance to our society. (G.M.C. turns to the M.H.A. and speaks to him)—Most High Alchemist, has the first ordeal, the ordeal by taste, been prepared?

M.H.A.—Grand Master of Ceremonies, the ordeal by taste has been carefully prepared. From the ends of the earth we have sought and gathered strange herbs, exotic plants, rare and curious salts, bitter acids; and from them we have extracted and doubly refined essences of direst properties. They are now here, contained in these four beakers, carefully guarded from prying eyes.

G.M.C.—Well done, Most High Alchemist! Now tell these neophytes what their first trial is to be. Let them also realize that the penalty of failure is serious. Prepare them well, so that their puny minds will be strained to the utmost.

M.H.A.—Presumptuous wretches, termites in human form, hear ye my words. Within these four beakers are rare and costly materials. No true follower of science can fail to recognize them by taste. If you *should* fail, . . .

Members of Club—Woe be to those who fail!

M.H.A.—But let us proceed with the test. Listen! Carefully listen!

M.H.A. and A.A. (in unison)—

Here are slips of paper, with numbers one to four.
Also here are beakers, exactly four, no more.
Taste their contents; then carefully write
Just what they are. Be sure you're right.
The slips, give to our Master Grand.
Outside this place, then, take your stand.

M.H.A.—I have spoken. Proceed with this first ordeal, poor creatures, and may the spirits of all true alchemists guide your way.

(Suggested contents for the four beakers are: beaker #1 ground mustard, #2 ground ginger, #3 salt, #4 sugar.)

(Blindfolds which have been prepared for the initiates for the second ordeal are placed on the table in front of the G.M.C. Preparations for the second ordeal may be set up in another room and the initiates led to this room over strips of paper which

have been saturated with a solution of ammonium iodide. This paper, when dry, crackles if walked upon as the unstable ammonium compound breaks down. If desired other weird and startling effects can be introduced as the initiates are led from room to room. Certain members should be selected before the ordeal starts to apply the blindfolds to the initiates and guide them through this part of the ceremony. When this arrangement has been completed the initiates are ushered in and seated as before in the front row of seats. The same system of knocks and counterknocks at the door can be used before admission to the room is granted.)

G.M.C.—Initiates arise and listen carefully to this second ordeal which you must undergo. (Initiates stand)—Most High Alchemist, has the test by touch been prepared?

M.H.A.—Verily Grand Master. From the bowels of the earth we have procured rare specimens of living, crawling, soft-bodied, limbless creatures, which shun the light of day as a plague. We have brought here under almost insurmountable difficulty a strange poison which glows with a curious fire when touched by human hand. We have here also that all pervading substance,—a fluid which is the essence of vacuity itself. Even that rarest of all fluids is here, that liquid which dissolves human flesh into nothingness and renders the most noble of metals a stench of vapor.

M.H.A.—All are here, and all would-be sons of science should know them well. Most noble members of (***name of society***), blindfold these base worms who defile our meeting place and let us find out whether their sense of touch is as perverted as their sense of taste. (Initiates are blindfolded)—And now listen, depraved wretches. Listen to the rules that govern this second ordeal.

M.H.A. and A.A. (In unison)—

On this bench there has been set
A group of substances, dry and wet.
Place your hand within each one;
Feel their texture. Then when done
Take yourself outside this room;
There record what you presume
The substances were, you touched and felt.
Their names must be correctly spelt.

(Suggested substances: #1 boiled spaghetti, #2 grape nuts,

#3 empty, air, #4 salt water, electric shock administered through solution.)

(Initiates are led one at a time past the four prepared substances contained in large battery jars. They are then led outside, the blindfolds are removed and slips of paper are handed them on which to place the names of the substances they touched.)

(Initiates for the third time are ushered into the initiation room and seated. The Assistant Alchemist before knocking for admission collects the slips of paper which the initiates have filled out for the second ordeal.)

G.M.C.—And now, make ready for the third ordeal, the test of smell. Most High Alchemist, is all in readiness for this most exacting examination?

M.H.A.—Verily, Grand Master, the ordeal has been carefully prepared. In this first flask has been captured and concentrated the aroma of a delicate flower, its fragrance having been secured with meticulous care from its fragile petals. In this second flask, we have imprisoned a stench so vile as to offend the nostrils of the devil himself. In this third flask is a strange scent which reels the head and dulls the senses. In this last flask is concentrated a rare perfume; so exotic, so richly endowed, that maidens swoon and strong men faint as its piercing fragrance penetrates their innermost being.

But enough of this! Such description is lost on these dullards who so brazenly sit before us. Even now they smirk slyly as do fools who rush into the storm and invite the very elements to blast their frames. Fools they are, but foolish as they are, like beasts they can inhale, and inhale they shall. Wretches, gird yourselves; and may your nostrils not fail you nor your senses take leave of your bodies. Stand with head back. Stand and inhale as instructed.

(Initiates stand. Pieces of cotton batting are then dipped into the four solutions and held in turn close to the nostrils of the initiates. One odor at a time should be administered to the whole group before another is brought out. The following verses are read before each of the inhalations.)

M.H.A. and A.A. (in unison)—

(*1. Extract of vanilla*)

This flask contains a perfume rare;
'Tis fit for only maidens fair;

Smell, inhale it; know it well;
Just what it is you soon must tell.

(*2. Carbon disulphide*)

This flask contains an odor rank;
Sniff and smell its vapors dank;
Note its marking, number two;
What it is; that's up to you.

(*3. Ammonium hydroxide*)

This third is an essence of poisonous power.
Its destructive effect gains strength by the hour.
Breathe deeply and fully of this odor strong;
Just what the stuff is, you'll be asked 'ere long.

(*4. Amyl alcohol*)

This fourth is quite costly; by nature most rare;
It captures the senses. It carries you where
The world is romantic, exciting and gay—
But get down to earth; what it is you're to say.

(After the last inhalation, the initiates are handed slips of paper with numbers one through four written on them. After filling these out with a list of the odors inhaled, the initiates take their seats in the front row. The Assistant Alchemist gathers the slips and the fourth ordeal is immediately started.)

G.M.C.—And now to test your literate ability. Those who would join us must needs be well versed in both the speech of science and that other symbolic language which is called mathematics. Most High Alchemist, has the ordeal of literacy been prepared.

M.H.A.—Grand Master, the ordeal of literacy has been prepared. It has been designed to test the mightiest of intellects. It is an ordeal which strips the veneer of words from prattling, shallow speech and reveals the sham of all those pretentious upstarts who try to confuse with their foolish chatter and bombastic verbosity. (Speaks to initiates)—Stand up, wretches, and be prepared to have your narrow intellects exposed for what they are. And may your unordered, incapable, and futile brains not be wholly shattered by these questions which are now yours to answer.

(Initiates stand in a row facing G.M.C.) A list of scientific words and technical terms are submitted one at a time to the

initiates for spelling. If an initiate is unable to spell a word correctly he steps back out of line. Continue with list of words until all initiates have been failed.)

Word list

triphenylmethane	pyruvic acid
vacuum	piezo-electric
terephthallic acid	emission
stereoisomerism	joule
amoeba	flocculation
parallel	lyophile
haemoglobin	thallium
endosmosis	dyne, etc.
fugacity	

(Continue by having them solve mentally the following mathematical problems. As they fail, initiates are seated. Continue until all initiates have failed.)

Suggestive Problems

1) What is the value of y^{2x} if $x=0$ (1)
2) If $b=2a$ and $c=5a$, what does a plus b plus c equal in terms of a? (8a)
3) What number added to $\frac{1}{2}$ of 12 will give $\frac{1}{3}$ of 42? (8)
4) If the logarithm of 2.0 to the base ten is .301, what is the logarithm of 8.0 to the base ten? (.903)
5) A coin is thrown two times. What is the chance that heads appears both times? etc. ($\frac{1}{4}$ or .25)

(Each initiate is next made to read all or part of the following paragraph. Insist on exaggerated expression and gesture in the reading. Rate initiate on dramatic ability. The italicized parts of the paragraph lend themselves to explanation through pantomime.)

The kinetic theory assumes all gases to be composed of myriads of *tiny particles* (called atoms and molecules) separated from each other by *vast stretches of empty space.* It has been calculated that there are *40,000,000,000,000,000,000,000 air particles in a single deep breath of air.* Even so, the breath of air is still *largely empty space, so small is the air particle size.* These particles are in a *continuous and violent agitation,* and even when a gas appears to be completely at rest, the kinetic theory tells us that the gas is actually seething with motion as these gas particles *race madly about in random directions at enormous speeds.* In this chaotic state, particle collisions are continually taking place. The kinetic theory assumes these *collisions to be perfectly elastic.* The kinetic theory explains gas pressure for the *continual bombardment* of the walls of a container confining the gas constitutes a *continuous force* which acts to push the wall outward.

(Club members may want to ask during the reading just what is meant by an "elastic collision," by "violent agitation," etc., and ask the initiate to demonstrate through gesture and acting the meaning of these phrases.)

G.M.C.—Fellow members of (*name of society*), in your estimation, have the ordeals prepared by our Most High Alchemist been satisfactorily administered?

Members—Yea, Grand Master.

G.M.C.—Is it your pleasure, then, that we now pass on the qualifications of these poor creatures?

Members—It is, Grand Master.

G.M.C.—Initiates, for the last time, take yourselves from this room. Await outside, fixed and immovable. This society has voted to ponder your requests for admission to its body. The society shall, of course, take into account the feebleness of your intellects and will try to be generous. Your fate is drawing near. May you survive its exactions. Go! (Initiates leave room.)

(The case of each initiate should be briefly discussed at this point and some agreement reached as to the order in which the initiates will be ushered singly into the room to be put through the final part of the ceremony. Initiates are then ushered in one at a time and told to stand at attention before the G.M.C. If desired, the whole group may be put through this final ceremony as a unit. Time is saved in this way, but the effect on the initiate is lessened.)

G.M.C.—To protect this society from those outside who would imperil us, it is necessary that what transpires here be kept secret. Do you hereby swear that no word of yours will ever reveal to the outside world what has taken place here, what is about to take place here or what may take place here in the future?

Initiate—I so swear (or) I do.

(At this point some horseplay may be introduced, the club handshake can be revealed, etc. Initiate then again takes his stand before the Grand Master.)

G.M.C.—Brother member of the (*name of club*), relax; for the informal part of your initiation it at an end. You have surmounted its hardships and passed its exacting demands. You have also stood up well under the abuse which has been heaped upon you; but as you know, no great goal was ever obtained but at some sacrifice.

Henceforth, consider yourself a full-fledged member of the (*name of club*). May you always take pride in this your society. At all times remain loyal to its fellow members and ever strive to uphold its high ideals.

And now members of (*name of club*), I give you (*name of initiate*), our newest member.

(Members of club rush from their seats and amidst vigorous hand-clapping give him a cordial welcome.)

A CENTURY OLD ARITHMETIC WORK BOOK

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A great many teachers are of the opinion that the idea of an arithmetic work book is comparatively new. This idea receives rather a blow when one encounters a book printed over 125 years ago, yet embodying many if not all of the ideas of our present day work book.

In my library, picked up in a second-hand store for a trifle a few years ago is a copy of *The Scholar's Arithmetic, or Federal Accountant*, by Daniel Adams, M.B. The copy is, according to the title page, of the eighth edition, and was printed in Keene, N. H., in 1813. It is autographed by Nathan Pool, of Salem, in 1815, coupled with the doggerel:

> Steal not this book for fear of shame
> For you see the owner's name.

According to the title page, the book presents:

"The whole in a form and method altogether new, for the ease of the master and the greater progress of the scholar."

In the preface we find that

" . . . this work . . . has relieved masters of a heavy burden of writing out Rules and Questions . . . the blank after each example is designed for the operation of the Scholar, which being first wrought upon a slate, or waste paper, he may afterwards transcribe into his book."

Here we find the essential idea of the work book; every problem has space for its solution in the book itself. Moreover, the spaces have been utilized for this purpose. In addition definitions are asked for, there are questions for the pupil to answer, and spaces for his answers are provided.

Reference to various parts of the book shows many interesting places for comparison with present day practice. Numeration is carried out to great length and the English notation is employed, that is, a billion is one followed by twelve, not nine, zeros; likewise a million billions are required to make a trillion. Instruc-

tions are given for reading numbers as large as quintillions, which in their notation would allow the reading of numbers of 35 digits.

Problems in multiplication and division are extremely complicated, the use of numbers of six and eight digits being common. One problem asks the number of seconds a man 21 years old has lived. After treatment of the fundamental operations, we come to the

> "rules essentially necessary for every person to fit and qualify them for the transaction of business. There are nine: reduction, fractions, federal money, interest, compound multiplication, compound division, single rule of three, double rule of three, and practice."

One wonders how many present day teachers could even tell what half these operations are. Various interesting sidelights on practices of former times are available. For example in place of the period or dot this text uses the comma as a decimal point. A man's wages are frequently quoted at two dollars a week; a man receiving eight per cent interest is referred to as an usurer. The problems in Federal money are especially interesting for we find such problems as to reduce the currency of New York and North Carolina to that of South Carolina and Georgia, or to that of New England; or to reduce either of these to federal money; or to shillings and pence.

In the third section of his text, the author treats operations occasionally useful. Included in such problems is such a task as the extraction of the square root, as well as detailed rules for working with duodecimals.

There is nothing particularly unusual in the type of problem used in the text, in fact such problems are common in books of the period. (Unfortunately it seems that many critics of our present day arithmetic seem to think we still retain some of these obsolete problems.) The unusual feature of this particular book seems to be that it is very definitely a combination of what we would now have as two separate books, a textbook and a work book. True enough the author suggests first working out the problem on a slate, but it is not unknown for pupils to follow the same plan now, in order to preserve a neat work book. The owner of the book in question sometimes made a mistake and work was crossed out. Moreover, when the book was once used, not only was a work book unavailable for second-hand use, a complete new text is demanded. Perhaps the publisher was not unfavorable, to say nothing of the author.

THEORY OF NUMBERS IN SECONDARY MATHEMATICS

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1. Introduction

This article is based on one of a series of lectures given at a course conducted by the Association of Mathematics Teachers of New York City during the term Sept. 1938 to Jan. 1939. The objectives of this series were stated to be:

1) To introduce those concepts of higher mathematics which are suitable for presentation on the secondary level.
2) To introduce those concepts of higher mathematics which make more profound the teacher's understanding of the mathematics he now teaches.

Besides these two objectives, this article will show how the theory of numbers can be used to help construct certain types of algebra and geometry questions.

The illustrations which follow are from classroom situations in various grades of mathematics. It will become obvious to the reader—if it has not yet occurred to him—that he has already been using concepts of number theory without realizing it. Like Moliere's character some may discover that they "have been using prose" all their lives. On the other hand some illustrations will require a knowledge of the elements of formal number theory for a complete appreciation. The writer has therefore thought it advisable to precede these illustrations with a brief outline of the elements of the theory of congruences, which will be needed.

2. Elements of the Theory of Congruences

Unless otherwise stated, all variables will represent integers.

Definition. If $a-b$ is a multiple of m, we shall say that a is congruent to b modulo m. In symbols we write $a\equiv b$, mod. m. The latter is called a congruence.

The following theorems are proven in any elementary work on the theory of numbers (see Hall & Knight, *Higher Algebra*, chapter 30).

1. If $a\equiv b$, mod. m, then $a+c\equiv b+c$, mod. m.
2. If $a\equiv b$, mod. m, then $a-c\equiv b-c$, mod. m.
3. If $a\equiv b$, mod. m, then $ac\equiv bc$, mod. m.

4. If $ar \equiv br$, mod. m, and if m and r have no common factors, then $a \equiv b$, mod. m.
5. If $ar \equiv br$, mod. m, and if m is divisible by r, then $a \equiv b$, mod. (m/r), (but not necessarily mod. m).
6. If $a \equiv b$, mod. m, then any multiple of m may be added to or subtracted from either side of the congruence. This summarizes theorems 1, 2, 3 above.

To apply these theorems, let us consider this problem. For what values of x, will $(11x-17)/4$ be integral. Since $11x-17$ is to be a multiple of 4, then $11x \equiv 17$, mod. 4; (def.).

Then $11x-8x \equiv 17-16$, mod. 4; (theorem 6).
$3x \equiv 1$, mod. 4.
Therefore $3x \equiv 1+8$, mod. 4; (theorem 6).
So that $x \equiv 3$, mod. 4; (theorem 4).

This means that $x-3$ is a multiple of 4, say $4t$. Therefore $x=4t+3$, where t is any integer—positive or negative.

3. Classroom Illustrations

As the first classroom illustration, let us consider a fraction such as $(3x-7)/4$. In a first term algebra class, the teacher may wish this to be evaluated for some given value of x. If the teacher wishes the result to be integral, he must first do the equivalent of solving the congruence $3x \equiv 7$, mod. 4. That is, $3x \equiv 3$, and $x \equiv 1$, mod. 4. So that $x=4t+1$.

Before the reader dismisses this illustration as being trivial, let him consider that whatever method he uses involves concepts of number theory. Knowing how to express them in the language of the Theory of Numbers is certainly the result of "a more profound understanding of the concepts he now teaches."

Even if he claims that he can determine the required value of x by trial, he may be using concepts of number theory. For if consecutive values of x be substituted as trials, the result will be integral within four trials. This is true because in the congruence $3x \equiv 7$, mod. 4, substituting a for x will give the same result as substituting $a+4t$ for x, by theorem 6.

Consider the formula $C=5/9(F-32)$, which transforms a Fahrenheit reading to a Centigrade reading. If in proposing this example the teacher wishes the result to be integral, he must do the equivalent of solving the congruence $F \equiv 32$, mod. 9.

When first teaching the graph of a linear equation, the teacher constructs a table of pairs of numbers x and y which satisfy

the given equation. An equation such as $3y+2x=7$ gives trouble since it seems that values of x cannot easily be found which will make y integral. Since for an accurate graph, integral values of x and y should be found when possible, this is an opportunity to teach the concept that at most three trials (in this case) are necessary to obtain an integer. This can be made plain to the student without the use of formal congruence notation.

The equation of a circle with center at the origin and radius r is $x^2+y^2=r^2$. This is most commonly taught with r integral. Less frequently the equation is given with r taking values such as $\sqrt{5}$, $\sqrt{8}$, $\sqrt{10}$, $\sqrt{13}$, $\sqrt{17}$, etc. These are quantities which can be constructed, each as the hypotenuse of some right triangle with integral sides. Thus $5=1^2+2^2$, $8=2^2+2^2$, $10=1^2+3^2$, $13=2^2+3^2$, and $17=1^2+4^2$.

To plot $x^2+y^2=17$, the student should first solve by trial for integral values of x and y. The distance from the origin to the resulting point $(1, 4)$ is then taken as the radius of the circle. Of course the points $(1, -4)$, $(-1, 4)$, $(-1, -4)$ could also have been taken. An equation with more than one unknown which is to be solved in integers is called a Diophantine equation. The study of Diophantine equations is one of the large sub-topics under the Theory of Numbers. In the problem under discussion, the student is required to solve mentally a quadratic Diophantine equation.

When constructing such examples, it will be of interest to the teacher to know the following theorem: every prime number of the form $4n+1$ can be represented as the sum of squares of two integers in one and only one way. An interesting proof of this theorem is to be found in the chapter on "General Continued Fractions" in volume two of Chrystal's *Algebra*.

Let us now consider another application. From the graph of the equation $y=x^2+3x-4$, determine the nature of the roots (or the roots themselves) of $x^2+3x-4=a$, where a is integral. If the roots are to be rational, then the discriminant $9+4(4+a)$ is a perfect square, say z^2, Therefore $a=(z^2-25)/4$. This requires the solution of the congruence $z^2\equiv 25$, mod. 4, or $z^2\equiv 1$, mod. 4. By trial we find $z\equiv 1$ or 3, mod. 4. Therefore $z=4t+1$ or $4t+3$, from which values of a can be determined.

When constructing type problems that are commonly taught in intermediate algebra, a knowledge of simple number concepts is useful. One illustration will suffice. How many pounds of coffee worth 30 cents a pound must be mixed with how

many pounds of coffee worth 40 cents a pound to produce a mixture of k pounds worth 34 cents a pound? The teacher wishes to determine k so that it and the answers will be integral. If x and y are the numbers of pounds of each, then the equations are $x+y=k$, and $30x+40y=34k$. These lead to $y=2k/5$. Obviously then, if y is to be integral, k must be a multiple of 5.

Strictly speaking every digit problem is a problem in the theory of numbers. But when such problems result in the formation of two equations with two unknowns, the stress in the classroom is on the formation and solution of these equations, rather than on the appreciation of the particular properties of the numbers involved.

However consider the following digit problem. In a certain number of two digits, the ten's digit is to the units digit as 3 is to 5. A second relationship is also stated for the two unknown digits. As most of our teaching is done today, this problem would have to be solved by the students in the traditional manner mentioned above. In fact the New York State Regents would allow no credit if a student reasoned that the answer was 35 without solving a pair of equations.

Simple number tricks which can be shown to students can often be explained in terms of easy number concepts. For example the well known short-cut for squaring a number ending in 5 is explained in more general form as follows:

$$[10a+b][10a+(10-b)]=100a(a+1)+b(10-b).$$

Since $b(10-b)<100$, there will be nothing to carry to the hundreds place. Thus to multiply 74 by 76, first multiply 4 by 6, and put the result in the ten's and unit's place. Then multiply 7 by 8 $[a(a+1)]$, and place the result before the 24. The answer is 5624. Similarly $83\times 87=7221$; $35\times 35=1225$. Occasion arises to use such a short cut in solving an equation like $x^2-25x-1250=0$, by the use of the formula. Finding the discriminant requires squaring 25, not an uncommon situation in Intermediate Algebra.

Other short cuts, such as for multiplying by 50, 25, or the like are all based on number concepts.

Tests for divisibility can be explained for the simple cases of 2, 3, 4, 5, 6, 8, 9. Each test can be based on the lemma that if $A=B+C$ and if B and C are each divisible by r, then A is divisible by r.

Consider the general representation of a number $N=a+10b+100c+1000d+\cdots$

1) If a is divisible by 2 or 5, then since $10b+100c+\cdots$ is divisible by 2 or 5, N must be divisible by 2 or 5.
2) If $a+10b$ is divisible by 4, then since $100c+1000d+\cdots$ is divisible by 4, then N must be divisible by 4.
3) If $a+10b+100c$ is divisible by 8, then since $1000d+\cdots$ is divisible by 8, N must be divisible by 8.
4) If $a+b+c\cdots$ (i.e. the sum of the digits) is divisible by 3 or 9, then since $9b+99c+\cdots$ is divisible by 3 or 9, N must be divisble by 3 or 9.
5) If tests (1) and (4) show that N is divisible by 2 and 3, then N is divisible by 6.

Other combinations and generalizations will occur to the reader.

The following tests (necessary but not sufficient) for perfect squares should be of interest to teachers. The first that every perfect square must end in one of 0,1,4,5,6,9 is obvious and doubtless commonly used. The second test is not as well known. It is based on the same principle as that used in casting out nines. Casting out nines from a number means subtracting nine from the number as many times as possible without obtaining a negative result. For example: 52 becomes 7, by subtracting 45. Notice that 7 is the same as the sum of the digits of 52. Consideration of (4) in the previous section and theorem 6 at the beginning of this article will show why this should be so.

Now a number x must be congruent to one of 0,1,2,3,4,5,6,7,8, mod. 9. Therefore x^2 must be congruent to 0,1,4,9,16,25,36,49, 64, mod. 9—or to 0,1,4,0,7,7,0,4,1, mod. 9, the last step being obtained by subtracting a sufficient number of nines from the step before (permitted by theorem 6).

Expressed in words this means that a necessary condition that a number be a perfect square is that the sum of its digits be congruent to one of 0,1,4,7, mod. 9. For example 36425 cannot be a perfect square because $3+6+4+2+5\equiv 2$ mod. 9.

A similar test for perfect cubes states that a necessary but not sufficient condition that a number be a perfect cube is that the sum of its digits be congruent to 0 or 1 or 8, mod. 9.

While on the topic of divisibility, let us consider the formula $S=n(a+l)/2$, for the sum of n terms of an arithmetic progression. If a, and d the common difference, are both integral, our intuitive number sense tells us that S must be integral. For a more mathematical proof, use the form

$$S=n[2a+(n-1)d]/2=na+n(n-1)d/2.$$

Since either n or $n-1$ must be divisible by 2, $n(n-1)d/2$ is integral, and so too is S.

The identity $S=a(r^n-1)/(r-1)=a(r^{n-1}+r^{n-2}+\cdots+1)$ can be used to show a similar thing for the sum of a geometric progression, with a and r both integral, and conditions for convergency.

That ${}^nC_r=n(n-1)(n-2)\cdots(n-r+1)/r!$ must be integral is obvious from an interpretation of ${}^nC_r$. For a more profound understanding every teacher should be familiar with the mathematical proof based on induction; (see *Higher Algebra*—Hall & Knight, p. 345).

The congruence notation invented by Gauss is very convenient. Learning to use it is like adding to one's vocabulary. This recommendation is of course not intended for the student, but for the teacher. Consider, for example the conditions under which $(-1)^r=(-1)^s$. One way of stating the conditions would be to say that if r and s are both even or are both odd, then $(-1)^r=(-1)^s$. A much neater way is to say that if $r\equiv s$ mod. 2, then $(-1)^r=(-1)^s$. Similarly to explain when $i^r=i^s$ $(i=\sqrt{-1})$ without congruences, would be a little long winded. In the language of congruences, we say if $r\equiv s$ mod. 4, then $i^r=i^s$. Likewise, if a is a root of $x^n=1$, then we may say that if $r\equiv s$ mod. n, then $a^r=a^s$. If $\sin x=\frac{1}{2}$, then all the roots of this equation can be succinctly expressed by the congruences $x\equiv 30$ mod. 360, and $x\equiv 150$, mod. 360.

The latter four examples can be profitably discussed in the classroom without the use of the congruence notation.

The topic of prime factors of integers has several applications of interest to teachers and of importance for the classroom. The fundamental theorem of the Theory of Numbers states that every integer can be expressed in one and only one way in terms of its prime factors. While this appears obvious with integers, it is not always so in the analogous situation with algebraic expressions. For example the factors of $2x^2-8$ may be given by one student as $(2x-4)(x+2)$, and by another as $(x-2)(2x+4)$. The writer has found that students take this situation to prove that an algebraic expression may be factored in more than one way. However it should be pointed out to them that the unique factorization theorem applies to algebraic expressions within the experience of the students, as well as to numbers. Thus both answers are equivalent to $2(x+2)(x-2)$. However mention might be made that in other number realms

factorization in terms of primes is not unique. For example in the realm of algebraic numbers,* $21=3\times 7=(4+\sqrt{-5})(4-\sqrt{-5})=(1+2\sqrt{-5})(1-2\sqrt{-5})$.

It is useful to recognize a perfect square when it is expressed in terms of primes. The power of each prime involved must obviously be even. Thus $2^4 3^2$ is a perfect square, whereas $2^4 3^3$ is not. This concept can be applied in several cases which arise in the classroom. First consider the transformation of $\sqrt{98}$ so that the number under the radical is a minimum (vaguely referred to by some, as "simplification"). If we write $98=2\times 7^2$, then the perfect square is picked out at once since it is an even power of the prime seven.

Next consider the problem of rationalizing the denominator of $1/\sqrt{150}$. If we write this as $1/\sqrt{2\times 3\times 5^2}$, we can see there are lacking factors of 2 and 3 to have the latter occur in even powers. This suggests multiplying the numerator and denominator by $\sqrt{2\times 3}$ or $\sqrt{6}$.

Similarly a perfect cube can be recognized by the fact that the powers of its primes are each multiples of three. Thus to rationalize the denominator of $1/\sqrt[3]{24}$, express it as $1/\sqrt[3]{2^3 3}$. The 3 is now of the first power; therefore it requires the extra factor 3^2 to make it a perfect cube. This suggests that we multiply numerator and denominator of the original fraction by $\sqrt[3]{9}$.

In intermediate algebra a simple proof can be given of the irrationality of $\sqrt{2}$ or $\sqrt{3}$, etc. Thus if we assume $\sqrt{2}=a/b$, a and b being integers relatively prime to each other, then $2b^2=a^2$. In other words $2b^2$ is a perfect square. But in this case the factor 2 is contained an odd number of times, since it is already contained either no times or an even number of times in b^2. Therefore $2b^2$ cannot be a perfect square. This proof is easily adapted to prove the irrationality of other surds like $\sqrt[3]{7}$, etc.

Thus far most of the illustrations given have been related to classroom material. The next few sections will deal with problems which might very well arise with the teacher when he is constructing examination questions.

These problems will all require the solution of Diophantine

* An algebraic number is one which is the root of some algebraic equation. For example, 3 is a root of $x-3=0$; $1+2\sqrt{-5}$ is a root of $x^2-2x+21=0$; and similarly for the others.

equations;—that is, equations with more than one unknown, which are to be solved in integers.

The first and best known of these is the equation $x^2+y^2=z^2$, which arises from the Pythagorean relationship among the sides of a right triangle. It is a common practice to have students memorize the frequently occurring combinations: 3,4,5;5,12,13 and their multiples. Does it not make for a more profound understanding on the part of the teacher, if he can derive formulas which will give all the integral solutions.

There have been many solutions given for this equation. A solution suitable for presentation to a bright intermediate Algebra class was given by the author in the *American Mathematical Monthly* for April, 1939. The solution here given utilizes a technique more widely applicable to the problems we have to deal with.

The technique referred to, states that if $xy=uv$ (all integers), then we may set $mx=nu$, and $ny=mv$, whatever m and n may be. Thus from $x^2+y^2=z^2$, we have $x^2=(z+y)(z-y)$, from which we may let $qx=p(z+y)$ and $px=q(z-y)$, Solving for x and y we obtain $x=2pqz/(q^2+p^2)$, $y=(q^2-p^2)z/(q^2+p^2)$. Since x and y are to be integers we let $z=t(q^2+p^2)$, so that $x=2tpq$ and $y=t(q^2-p^2)$, t, p, and q being any integers.

Here we have a solution in integers, of the right triangle. This suggests another problem important for elementary geometry. Can we find a right triangle with integral sides and integral segments made on the hypotenuse by the altitude?

Let b and a be the legs of a right triangle, c its hypotenuse and x and y the segments of the hypotenuse made by an altitude, and adjacent to b and a respectively.

We see that if a, b, c and x are integral, then y must be integral. Now $x=b^2/c$. Let d be the highest common factor of b and c. Let $b=db_1$, $c=dc_1$ (so that $a=da_1$). Then b_1 and c_1 have no factor in common. Since $x=db_1^2/c_1$ is to be integral, d must be a multiple of c_1. Therefore let $d=tc_1$, in which case $x=tb_1^2$, $c=tc_1^2$, $b=tc_1b_1$, $a=\sqrt{c^2-b^2}=tc_1a_1$, where a_1, b_1, c_1 are integral sides of a right triangle, prime each to each, and t is any integer.

For example, if b_1, a_1, c_1 are 3, 4, 5 respectively, then $d=5t$, and b, a, c are $15t$, $20t$, $25t$ respectively, and $x=9t$ and $y=12t$. Other specific cases give numbers which are too large for use in the classroom.

We proceed now to a problem from algebra. Consider the

trinomials x^2+5x+6, x^2+5x-6, x^2-5x+6, x^2-5x-6. Notice that they can all be factored. When presenting drill material to students who are learning factoring, such examples are useful in that they compel the student to take particular care in the choice of signs. This suggests the following problem. For what values of a and b, will $x^2 \pm ax \pm b$ all be factorable?

Obviously we need consider only x^2+ax+b and x^2+ax-b, since if these are factorable, then the others will also be factorable.

Let (1) $x^2+ax+b=(x+p)(x+q)$ and (2) $x^2+ax-b=(x-r)(x+s)$, where a, b, p, q, r, s are all positive integers.

Then (3) $b=pq=rs$, and (4) $a=p+q=s-r$.

From (3) applying the technique previously referred to, we assume (5) $np=mr$ and $mq=ns$, or (6) $p=mr/n$ and $q=ns/m$.

Substituting for p and q in (4), we obtain $mr/n+ns/m=s-r$, or $r(m^2+mn)=s(mn-n^2)$.

Now let $r=t(mn-n^2)$ and $s=t(m^2+mn)$, where t is any integer. Then $rs=b=t(mn+m^2)(mn-n^2)$; and finally $b=tmn(m^2-n^2)$ and $a=t(m^2+n^2)$. Table I is a short table of special values.

TABLE I

m	n	t	a	b	trinomial
1	2	1	5	6	$x^2 \pm 5x \pm 6$
1	2	2	10	24	$x^2 \pm 10x \pm 24$
1	2	3	15	54	$x^2 \pm 15x \pm 54$
1	4	1	17	60	$x^2 \pm 17x \pm 60$
1	4	2	34	240	$x^2 \pm 34x \pm 240$
23	3	1	13	30	$x^2 \pm 13x \pm 30$
3	4	1	25	84	$x^2 \pm 25x \pm 84$

A similar, though less useful problem (from the classroom point of view), is to determine a, b, c so that $ax^2 \pm bx \pm c$ are all factorable. The treatment of the previous problem is not easily applied here. We therefore proceed differently. The above trinomials will be factorable if the discriminants $b^2 \pm 4ac$ are each perfect squares. Therefore let $b^2-4ac=x^2$, and $b^2+4ac=y^2$.

Therefore (1) $(b+x)(b-x)=4ac$

(2) $$(b+y)(b-y)=-4ac.$$

From (1) we assume $b+x=4ap$ and $(b-x)p=c$, p being any integer. From (2) we assume $y+b=+4aq$, and $q(y-b)=-c$, q being any integer. If we eliminate x and y and assmue $c=4pq(q-p)t$ (as suggested in the solution, we obtain $a=(p+q)t$, $b=2(p^2+q^2)t$, $c=4pq(q-p)t$, p, q, t, being any integers.

For a short table with $t=1$, see Table II.

TABLE II

p	q	a	b	c	trinomial
1	2	3	10	8	$3x^2 \pm 10x \pm 8$
1	3	4	20	24	$4x^2 \pm 20x \pm 24$
1	4	5	34	48	$5x^2 \pm 34x \pm 48$
2	3	5	26	24	$5x^2 \pm 26x \pm 24$
2	4	6	40	64	$6x^2 \pm 40x \pm 64$
3	4	7	50	48	$7x^2 \pm 50x \pm 48$
1	5	6	52	80	$6x^2 \pm 52x \pm 80$

In trigonometry, the problem suggests itself of finding triangles with integral sides and one angle of 60°. If x, y, z are the sides of a triangle with an angle of 60° between x, and y, then by the law of cosines we have: $z^2=x^2+y^2-xy$. Therefore $(z+y)(z-y)=x(x-y)$. Let $q(z+y)=px$, and $p(z-y)=q(x-y)$. Solve for x and y and then let $z=t(p^2-pq+q^2)$ as suggested in the solution, and we obtain $x=(2pq-q^2)t$, $y=(p^2-q^2)t$, and $z=(p^2-pq+q^2)t$. The trivial case of the equilateral triangle occurs when $2q=p$.

For a short table with $t=1$, see Table III.

TABLE III

p	q	x	y	z
3	1	5	8	7
4	1	7	15	13
5	1	9	24	21
5	2	16	21	19

Because of the identity $(y-x)^2+y^2-(y-x)y=x^2+y^2-xy$, x may be replaced by $y-x$ in Table III. The result is Table IV.

TABLE IV

x	y	z
3	8	7
8	15	13
15	24	21
5	21	19

The reader may be interested in working out the similar problem for the 120° integral triangle.

From plane geometry we have the formula for the area of a triangle, $k=\sqrt{s(s-a)(s-b)(s-c)}$, in terms of the sides. To solve for integral sides which produce an integral area, we proceed as follows.

Let $a=\alpha+\beta$, $b=\beta+\gamma$, $c=\gamma+\alpha$. Then the perimeter, $2s=2(\alpha+\beta+\gamma)$. Then $s(s-a)(s-b)(s-c)=\alpha\beta\gamma(\alpha+\beta+\gamma)=k^2$. Generalizing the technique used in the previous examples, we let $p\alpha=qk$, $q\beta=rk$, $r\gamma=u$, $u(\alpha+\beta+\gamma)=p$, where p, q, r, u are any integers. Then $\alpha=qk/p$, $\beta=rk/q$, $\gamma=u/r$, $\alpha+\beta+\gamma=p/u$. Eliminating α, β, γ and solving for k, we obtain $k=pq(pr-u^2)/ru(q^2+pr)$. Then $\alpha=q^2(pr-u^2)/ru(q^2+pr)$, $\beta=p(pr-u^2)/u(q^2+pr)$, $\gamma=u/r$. But for integral values multiply through by $ru(q^2+pr)t$ and we obtain finally $\alpha=q^2(pr-u^2)t$, $\beta=pr(pr-u^2)t$, $\gamma=u^2(q^2+pr)t$.

When substituting for specific cases, it will be found that some triangles turn out to be right triangles. Such cases could have been discovered through the first illustration in this section. Therefore only triads of sides of non-right triangles are given in Table V.

The solutions given in these problems are not general of course, so that specific cases known to the reader may have been omitted in the tables. It is hoped however that sufficient evidence has been given to show that at least an elementary knowledge of the Theory of Numbers is essential to the teacher, some of which can be taught informally to the student, and some of which will help him in constructing exercises.

Before closing this article, the writer wishes to suggest an-

other direction which might be taken in applying number theory to the field of testing. This can best be shown through an illustration. In an intermediate algebra test one question asked that students solve for x and y in the equations $3x+y=4$, $x^2=2y-8$. Eliminating y results in a factorable quadratic in x. However some of the students before substituting for y, transposed in the second equation and obtained $x^2-2y=8$, a mistake in sign. The resulting quadratic was again factorable. Other students solved for x in the linear, obtained $x=(4-y)/3$ correctly and then substituted in the quadratic. However, some of them in squaring $(4-y)/3$ obtained $(16-8y+y^2)/3$, an error in the denominator. But again the resulting quadratic was

TABLE V

a	b	c	Area
6	5	5	12
6	29	25	60
7	20	15	42
11	13	20	66
14	13	15	84
24	53	35	336
36	29	25	360
39	25	40	468
66	53	35	924

factorable. If the quadratic in either of these cases had not been factorable, the student would have had to use the formula and so taken more time for this problem than was planned by the teacher. As a result, the other questions could not have been judged fairly, since the student might have had to rush. This general problem then suggests itself. A teacher should determine what types of errors are made most frequently by his students. He should then, if possible, construct problems so that their difficulty will be the same whether done correctly, or whether the errors foreseen are made. This will be difficult or impracticable in some cases. But in those cases which are practicable, a knowledge of number theory will help.

NEW MATERIALS FOR THE TEACHING OF PHYSICS

A. H. Gould
Boys' Technical High School, Milwaukee, Wisconsin

Because the subject of new physics equipment was pretty well exhausted in this magazine's June issue, I shall confine my attention to literature and visual aids of interest to physics teachers.

You may be disappointed in glancing at the list of motion picture films for physics, appended here, to note that only two are quite recent; and the producing companies have not indicated that more are soon forthcoming. In making up this list I put down the few films most favored by a group of physics instructors of my acquaintance. I suppose we must realize that the making of a sound film of this type is a long, arduous, and expensive affair and we should be grateful for the few we do get since they are of excellent quality. True, you may be able to pick out a defect here and there, like that of the animated drawing of electrons dancing like Brownian particles and never bumping, but the general quality is high. In one animation the heating system of a house is shown with a cold air intake and the heated air forcing its way out the crannies; and against something of this kind we might protest since this system has certainly been obsolete for the past fifteen years; but you will find few defects in most of these films.

You may find that two of the newer films "Sound Waves and Their Sources" and "Fundamentals of Acoustics" are somewhat advanced but still well adaptable for high school use. In the latter picture, animation, sound, and motion combine in an extraordinary manner to explain timbre and reverberation.

Some areas of physics are very poorly served by films at present. We have one passable film to explain sound recording and projection but the British commentator's voice gives the students some trouble in this instance and the technical explanation is not as clear as it might be. Recently one of our projector manufacturers tried to fill this need with a commercial film but the amorous, not to say torrid, opening scenes rule it out for the high school and the footage devoted to explanation is much too brief anyhow. We need a comprehensive and unified discussion of flight theory with views and comments on modern types of planes. We have no clear exposition of the

principles of common types of electrical motors and their applications. Television has now advanced to such a stage that filming should involve but little risk of obsolescence. In radio we have only one very old filming, a General Electric picture, "The Wizardry of Wireless," and, while this is still useful, the subject would bear more modern treatment.

In glass slides there seems to be nothing new offered. In film slides we find only one new set, pictures taken from the illustrations in a physics text. It seems to me there is sore need of greater enrichment of physics teaching in this medium. I thoroughly believe in motion pictures where motion is indispensable but certainly there are many topics that can be treated just as adequately in still pictures and at less expense in time and money. And to those of us who find our visual aid budget reduced by hard times the supplementary material in film slides should prove an important adjunct. Do we teachers underestimate the worth of these film slides because we have become enthralled with the magic of motion? Do we realize that their use is growing to enormous proportions in industrial and commercial fields? The several thousand county agents of the United States Department of Agriculture use them intensively in their lectures. The president of General Motors referred to film slides as "the greatest plan for putting ideas into men's heads that ever came into selling." But the company uses the film slides for the instructing and informing of its workers and reserves the motion picture for its psychological effect upon prospective buyers. This company has invested more than one million dollars into film slides.

Perhaps your objection to film slides has been their lack of brilliancy but this difficulty can be overcome with one of the new film slide projectors with a 200 or a 300 watt lamp and a beaded screen which you will find much superior to the plain silver type if you keep it covered to prevent surface fouling.

On the matter of our needs in physics I approached Mr. W. W. Dewey of Dewey and Dewey, Kenosha, Wisconsin, who list more than one thousand titles in educational film strips but carry only the usual slight list in physics. For this lack of material in our field he says we ourselves are responsible since he has been unable to find a physics teacher with the spare time or energy to undertake the editing of a series of physics pictures. When I expressed astonishment at the great list of agricultural film slides available he pointed out that these were edited by

the United States Department of Agriculture to fill the needs of its county workers; but since we have nothing comparable to this department to do our work it is up to us to help ourselves. Mr. Dewey is still looking for a physics teacher to help him. There must be some among us with faith in the future of this medium and with vision and ability to give us something really fine in return for a fair royalty and some distinction in this field.

There are several very good commercial film strips with manuscripts that you may obtain on a permanent loan basis for the asking if you write to the proper department of the General Electric Company. (Note the appended list of sources.) Their "History of the Electrical Industry" you will find very interesting and instructive. Each year they release a new strip on "Some Recent Developments in the Electrical Industry" and the last one, reviewing 1938, shows, among other unique items, views of the new high intensity, water-cooled mercury lamp and of the famous turbine-electric locomotive. This company has a list of free motion pictures that might interest you. If you are equipped for 35 millimeter sound film, their "Early Experiments of Michael Faraday" showing Sir William Bragg repeating Faraday's procedure with the original apparatus should appeal to you.

Periodical Publications for Physics Teachers

1. "Aims of the Laboratory," Max Kostick, School Science and Mathematics, Nov. 1939.
2. "The Classroom Film," R. E. Davis, School Science and Mathematics, Oct. 1939.
3. "Demonstrating How Motion Pictures are Made and Shown, Using Ordinary Visual Equipment," W. L. Fenner, School Science and Mathematics, April 1939.
4. "Diethylphthalate for Hand Made Lantern Slides," Grant Paterson, *The Educational Screen*, Oct. 1939. (Paper transparencies.)
5. "Eastern Association of Physics Teachers Meetings," School Science and Mathematics, Feb., May, Oct. 1939.
6. "The Effectiveness of the Sound Motion Picture in College Physics," C. J. Lapp, *American Physics Teacher*, Aug. 1939.
7. "Experiments with a Mirror of Variable Curvature," W. V. Burg, School Science and Mathematics, March 1939.
8. "The Factors Determining Liquid Pressure," W. A. Porter, School Science and Mathematics, Feb. 1939.
9. "Finding Candle Power with a Sightmeter," W. A. Porter, School Science and Mathematics, Oct. 1939.
10. "Heat and Kinetic Theory from the Standpoint of the Scientific Method," Winston Gottschalk, School Science and Mathematics, Dec. 1938.
11. "The Laboratory—Pro and Con," J. M. Levelle, School Science and Mathematics, Oct. 1939.

12. "The Lecture Room Stop Watch," F. H. Wade, SCHOOL SCIENCE AND MATHEMATICS, Apr. 1939.
13. "Making Laboratory Work in Physics Functional," C. P. Cahoon, SCHOOL SCIENCE AND MATHEMATICS, Jan. 1939.
14. "A Multi-Use Photoelectric Cell Set Up," Wm. A. Porter, SCHOOL SCIENCE AND MATHEMATICS, March 1939.
15. "The Plane Mirror Experiment," Glen W. Warner, SCHOOL SCIENCE AND MATHEMATICS, March 1939.
16. "Possible Techniques for the Development of Scientific Attitudes," Carlton F. Power, SCHOOL SCIENCE AND MATHEMATICS, March 1939.
17. "Professor of Physics in a Teachers College," A. P. Temple, *Education*, March 1939.
18. "Scientific Features of the Common System of Weights and Measures," K. Gordon Irwin, SCHOOL SCIENCE AND MATHEMATICS, Feb. 1939.
19. "A Science Teacher Looks at the Classroom Film," H. Emmett Brown, SCHOOL SCIENCE AND MATHEMATICS, Apr. 1939.
20. "Simplified Television Demonstration," *Popular Mechanics*, Sept. 1938.
21. "Some Reflections on the Teaching of Physics," Robert B. Lindsay, SCHOOL SCIENCE AND MATHEMATICS, May 1939.
22. "What the College Expects of an Elementary Course in Physics," John C. Slater, SCHOOL SCIENCE AND MATHEMATICS, Feb. 1939.

PERIODICAL PUBLICATIONS FOR PHYSICISTS

1. "The Acoustics of Auditoriums and Classrooms," Richard L. Brown, SCHOOL SCIENCE AND MATHEMATICS, May 1939.
2. "Atomic Clocks," *Time*, May 9, 1938.
3. "Concepts of the Atom," Frederick E. White, SCHOOL SCIENCE AND MATHEMATICS, May 1939.
4. "The Doctor Consults the Physicist," G. R. Harrison, *Atlantic Monthly*, May 1939.
5. "Eyes that See Through Atoms," G. R. Harrison, *Scientific American*, Oct. 1939.
6. "Forces which Govern the Atomic Nucleus," *Scientific Monthly*, Oct. 1938.
7. "Here Comes Television," O. B. Hanson, *Scientific American*, Apr. 1939.
8. "Incomparable Promise or Awful Threat," A. G. Ingalls, *Scientific American*, July 1939.
9. "Ionosphere," E. O. Hulburt, *Scientific Monthly*, May 1939.
10. "Making New Atoms in the Laboratory," E. U. Condon, *Scientific American*, Nov. 1938.
11. "Personalities of the Elements," S. J. French, *Scientific American*, June 1938.
12. "Splitting of Uranium Atoms," M. A. Tuves, *Scientific Monthly*, March 1939.
13. "Television and the Coaxial Cable," R. L. Ives, *Science News Letter*, Nov. 20, 1937.
14. "What Keeps the Stars Shining," H. W. Russell, *Scientific American*, June, July 1939.

BOOKS FOR PHYSICISTS

1. *Albert Einstein: Maker of Universes*, H. Gordon Garbedian, Funk, \$3.75.
2. *Atoms in Action*, George Russell Harrison, Morrow, \$3.50.

3. *Cosmic Rays*, H. J. Braddick, Cambridge (Macmillan), $1.75.
4. *Cosmic Rays*, R. A. Millikan, Cambridge (Macmillan), $2.50.
5. *The Evolution of Physics*, A. Einstein and L. Infeld, Simon and Schuster, $2.50.
6. *The Field of Physics*, Daniel L. Rich, Edwards, $2.50.
7. *Matter and Light, The New Physics*, Louis de Broglie, Norton, $3.50.
8. *On Understanding Physics*, W. H. Watson, Macmillan, $2.25.
9. *The Philosophy of Physical Science*, Sir Arthur Eddington, Cambridge (Macmillan), $2.50.
10. *Physical Science in Modern Life*, F. G. Richardson, Van Nostrand, $3.
11. *Report of the Secretary of the Smithsonian Institute for 1938*, 119 pp., Government Printing Office, 15¢.
12. *Superconductivity*, D. Schoenburg, Cambridge (Macmillan), $1.75.
13. *Ultrasonics and their Scientific and Technical Applications*, Ludwig Bergmann, translation by H. Stafford Hatfield, Wiley, $4.

Motion Pictures for Physics Teaching
16 mm

1. Air Currents and Theory of Streamlining, 1 reel, sound, $1.50 per day, Y. M. C. A. (Ask for No. GS 141.)
2. Behavior of Light, 1 reel, silent, Eastman Kodak Co.
*3. Electrodynamics, 1 reel, sound. (Write SVE, for silent film.)
*4. Electrons, 1 reel, sound.
*5. Electrostatics, 1 reel, sound.
*6. Energy and Its Transformations, 1 reel, sound.
*7. Fundamentals of Acoustics, 1 reel, sound.
8. How Talkies Talk, 1 reel, sound, with notes, $1.25 per day, Univ. of Wis. (Gaumont British film.)
9. Induced Currents, 1 reel, silent, 75¢, Univ. of Wis., Eastman Kodak Co.
*10. Light Waves and Their Sources, 1 reel, sound.
*11. Molecular Theory of Matter, 1 reel, sound.
*12. Sound Waves and Their Sources, 1 reel, sound.
13. The Power Within, 2 reels, silent, 30¢ per day, Univ. of Wis., or U. S. Bureau of Mines.

Motion Picture Film Directories

1. Free Films for Schools. De Vry corp., 1111 Armitage Ave., Chicago, Ill. 25¢.
2. "1000 and One" Film Directory. Educational Screen, 64 East Lake St., Chicago, Ill. 75¢.
3. Victor Directory of 16 mm Film Sources, Directory Editor, Victor Animatograph Corp., Davenport, Iowa. 50¢.

Slides and Film Slides for Physics

1. American Institute of Steel Construction, 200 Madison Ave., New York City, Slides on bridges and steel construction loaned free.
2. Cambosco Scientific Co., 37 Antwerp St., Brighton Sta., Boston, Mass. Film slides.
3. The Chicago Apparatus Co., 1735 N. Ashland Ave., Chicago, Ill. Film slides. (Copy of text illustrations.)
4. Dewey and Dewey, Kenosha, Wis. Film slides.
5. Edited Pictures System, Inc., 330 West 42nd St., Chicago, Ill. Film slides.

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* Obtain from Univ. of Wis. at $1.25 per day or write Erpi Classroom Films Inc., 35-11 Thirty-fifth Ave., Long Island City, N. Y., for nearest source. Manuscript accompanies each film.

6. General Electric Company, Visual Instruction Section, 1 River Road, Schenectady, N. Y. Film slides with manuscript, permanent loan.
7. Keystone View Co., Meadville, Pa. Slides.
8. Society for Visual Education, Inc., 100 E. Ohio St., Chicago, Ill. Film slides.
9. Stillfilm, Inc., 4703 W. Pico Blvd., Los Angeles, Calif. Film in slide width with adapter.

Motion Picture Sources
Commercial Films (Free)

1. American Institute of Steel Construction, 200 Madison Ave., New York City. Sound and silent.
2. Bausch and Lomb Optical Co., Rochester, N. Y. Silent.
3. General Electric Co., Visual Instruction Section, 1 River Road, Schenectady, N. Y. Many good films, sound and silent.
4. Goodyear Tire and Rubber Co., Inc., Motion Picture Dept. Akron, Ohio. Silent films.
5. National Council of the Y. M. C. A., Motion Picture Bureau, 19 South LaSalle St., Chicago, Ill. Sound and silent.
6. The United States Bureau of Mines, 4800 Forbes St., Pittsburgh, Pa. Silent.
7. The United States Steel Corp., Industrial Relations Dept., 71 Broadway, New York City.
8. The Western Electric Company, 195 Broadway, New York City. Sound and silent.

Non-Commercial Films

1. Bell and Howell Co., 1815 Larchmount Ave., Chicago, Ill.
2. Bray Pictures Corp., 729 Seventh Ave., New York City.
3. The Eastman Kodak Co., Teaching Films Div., Rochester, N. Y.
4. SVE—Society for Visual Education, Inc., 100 E. Ohio St., Chicago.
5. Visual Education Dept. of Your State University. A majority of the state universities have such a bureau.
6. Visual Education Service, 131 Clarendon St., Boston, Mass.
7. Y. M. C. A. Motion Picture Bureau, 19 So. LaSalle St., Chicago, Ill.

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62 YEARS IS AVERAGE EXPECTANCY OF LIFE

Babies born today can expect 62 years of life on earth, the Population Association of America was told by Dr. Louis I. Dublin, Metropolitan Life Insurance Company vice president and statistician.

Attributing a steady lengthening of the life span in this country to the improved level of living and to medical and sanitary advances since father's and grandfather's day, Dr. Dublin said:

"Persons living today are definitely outliving the expectation of life which they had at the time of their birth. Of the persons now 65 years of age, fully one-third would not be living today had the conditions prevailing at their birth remained unchanged."

Persons born about 1870, he explained, had an expectation of living 41½ years, on the basis of mortality rates prevailing when they were born. But because of improving conditions, the average person born then actually did live longer—46½ years.

A RÉSUMÉ OF SOME OF THE OUTSTANDING EDUCATIONAL PICTUROLS ON BIRDS

LYLE F. STEWART
Oak Park and River Forest Twp. High School, Oak Park, Ill.

Each type of projected visual aid—silent motion picture, sound motion picture, glass slide and picturol (filmstrip)—has special advantages. Since space does not permit a description of all of the desirable visual aids on birds, an attempt has been made to choose some of the outstanding and unusual picturols for review.

Still pictures provide opportunity for prolonged observation and detailed analysis of given situations. The picturol may be used to an advantage when it is desirable to show a relatively large number of still pictures to provide development, contrasts or comparisons.

BIRDS OF A FEW REPRESENTATIVE ORDERS, Produced by The Chicago Academy of Sciences for the Society for Visual Education, Chicago (42 pictures; teacher's syllabus).

Most of the photographs in this picturol were taken on field expeditions sent out by the Chicago Academy of Sciences to make records of the bird, mammal and reptile life along the Gulf Coast of Louisiana. The nine orders with the number of pictured representatives of each order are arranged as follows: Colymbiformes (1), Pelecaniformes (4), Ciconiiformes (4), Anseriformes (1), Falconiformes (5), Megalornithiformes (2), Charadriiformes (9), Strigiformes (1), Passeriformes (5). The habits and characteristics of the representatives are very clear since two or three views were included when necessary to illustrate their outstanding traits.

BIRD NESTS, by Gayle Pickwell, Ph.D., *State College, San Jose, California* (26 pictures; teacher's syllabus).

This interesting picturol shows the different types of nests from the very simple to the very elaborate. The evolutionary sequence includes pictures of nests on the ground, a nest that floats in water, nests in weeds, bushes and trees, and nests in crevices in rocks and behind waterfalls. "Readers" placed on the filmstrip before each picture provide interesting and worthwhile information about each bird and nest. The readers are concise (16 to 23 words) and easily understood. The contents of

the readers on the filmstrip are printed in the teacher's syllabus in capital letters so that the sequence on the screen may be easily followed. The information included in each reader is supplemented in the teacher's syllabus by additional data on the activities of the birds and structures of their nests.

How Young Birds Get Food, Photographs and Legends by Gayle Pickwell, Ph.D., *State College, San Jose, California* (15 pictures; 15 "readers").

Pictures of a young Ptarmigan and Avocet which get their own food act as a general introduction to the remainder of the illustrations which show how birds in nests are fed by their parents. "Readers" placed on the filmstrip before each picture, describe how the parents obtain food and give it to their young. The readers (legends) although somewhat long, show careful editing; they do not give the impression of having been written down to the pupil level. Nevertheless, they should be easily understood by all upper grade and high school pupils. The birds pictured in the filmstrip include: Ptarmigan, Avocet, Pipit, Wren, Thrush, Woodpecker, Water Ouzel, White-tailed Kite, Turkey Vulture, Dove, Pigeon, and Hummingbird.

Beaks and Feet of Birds, Photographs and Syllabus by Gayle Pickwell, Ph.D., *State College, San Jose, California* (25 pictures; teacher's syllabus).

The photographs in this series are arranged according to the kinds of food that birds eat. The pictures show the beaks and feet of birds that catch fish, then, in order, beaks and feet of birds that are scavengers, seed-eating birds, a bird that eats nectar of flowers, and lastly some of the many specializations of beaks and feet of birds that eat insects. "Readers" on the filmstrip before each picture present worthwhile information to the class about the beaks and feet of each bird. The contents of the readers on the filmstrip are printed in the teacher's syllabus and supplemented by additional information on the relation of the structures of the beaks and feet to food-getting habits. Suggested questions for class discussion have been included at the end of the syllabus.

Habits of Sandpiper, Plover and Killdeer, Chicago Academy of Sciences (31 pictures—1 of sandpiper, 14 of plover, 11 of killdeer; teacher's syllabus).

This picturol includes very good photographs of male and female Plovers, eggs and young. The pictures of the Killdeer show how well nature has marked this bird for concealment against the white stones and dark soil when it incubates its eggs. The young Killdeer blend with the background in the photographs so that it is almost impossible to see them.

FAMILIAR BIRDS OF FIELD, FOREST AND MARSH, Chicago Academy of Sciences, Produced and Distributed by the Society for Visual Education, Chicago (33 pictures; teacher's syllabus).

Most of the photographs were taken by Alfred M. Bailey, Director of the Academy of Sciences. The pictures show the adult birds and nests with eggs or young of the following species: Kingbird, Towhee, Field Sparrow, Long-billed Marsh Wren, Redwing, Brown Thrasher, Mourning Dove, Goldfinch, Song Sparrow, Vesper Sparrow, Robin, Horned Lark, Lark Bunting, Virginia Rail, Water Ouzel, Red-shafted Flicker, and Woodcock.

SEA BIRDS OF BONAVENTURE ISLAND, Produced by the Chicago Academy of Sciences for the Society for Visual Education, Chicago (44 pictures; teacher's syllabus).

This series of pictures was taken on Bonaventure Island, a unique island off the coast of Quebec. It is one of the greatest bird islands on the North American Continent and is one of the last nesting places of the Gannetts in the New World. The first sixteen pictures include scenes of the coast, vegetation and human residents as well as general views of the bird-cliffs of the island. The remaining thirty-eight pictures show the adult birds, nests, eggs and young of the Puffins, Murres, Gannetts and Kittiwakes (small sea gulls). The photographs of the Gannetts are especially good.

BIRDS OF GREAT SALT LAKE, by Alfred M. Bailey, *Director, Chicago Academy of Sciences*, Produced and Distributed by the Society for Visual Education, Chicago (47 pictures; teacher's syllabus).

This picturol shows the interesting bird-life found on the islands of Great Salt Lake and the surrounding marshes. It includes photographs of the Black Tern, Franklin's Gull (revered by the Mormons), Mallard, Red-headed Duck, Long-

billed Curlew, American Avocet and Black-necked Stilt. There are nine pictures of the Ibis which show their colonies and activities in caring for their young. Six pictures illustrate the nesting and feeding habits of Brester's Egrets which are often found in the Ibis' colonies. The last eighteen pictures were taken on Hat Island in Great Salt Lake where thousands of water birds nest each year. These unusual photographs show the nests, eggs, development of young and flight of the Great White Pelican and Sea Gull.

CRUISING AMONG THE BIRD ISLANDS OF ALASKA—SPRING AND SUMMER, Chicago Academy of Sciences. Part I (47 pictures; teacher's syllabus), Part II (50 pictures; teacher's syllabus).

Part I includes scenes of the rugged coast, Indian villages, different types of vegetation, glaciers and fjords. Only nine of the 47 pictures of the first filmstrip (Part I) are of birds. The birds included are: Glaucous Winged Gull, Anklet, Short-billed Gull, Arctic Tern and Rock Ptarmigan. Although this filmstrip (Part I) does not show many birds, it provides excellent detailed information on the general environment and varying habitats of Alaska which may serve as a background for subsequent detailed study of animals and birds of that region.

Twenty-four of the 50 pictures of the second filmstrip (Part II) are of birds. The different species shown in their natural surroundings include: Humming Bird, Oregon Junko, Northern Raven, Alexander Willow Ptarmigan, Dixon's Rock Ptarmigan, Bald Eagle, California Murre, Black Oyster Catcher, Glaucous Gull, Tufted Puffin, Beal's Petrel, Forked-tailed Petrel and Rock Ptarmigan. Scenes of deep fjords, glaciers, moraines, bergs, abandoned gold mines, bear and deer are included among the pictures of the different birds.

The background information contained in these two filmstrips should make a definite contribution in helping pupils to form correct and lasting concepts of the Alaskan region and its bird life.

WILD WINGS ALONG THE GULF OF MEXICO, by Alfred M. Bailey, *Director, Chicago Academy of Sciences* (56 pictures—46 are pictures of birds; teacher's syllabus).

This series of pictures shows the wonderful bird life which crowd the sanctuaries of the Shell Keys and nearby marshes along the Gulf of Mexico. The first three photographs show the

varied plant life on the shell ridges. Three pictures show the inhabitants who are mostly descendants of the Acadians who settled the Louisiana Gulf Coast after they were banished from their own Acadia by the English. The birds pictured include: Geese, Bald Eagle, Heron, Snowy Egret, Duck Hawk, Brown Pelican, Florida Nighthawk, Black Skimmer, Laughing Gull, Least Tern, Foster Tern, and Cabot Tern.

Several interesting pictures emphasize the characteristics of the Terns. A series of outstanding photographs show the nests, eggs, young, and flying characteristics of the Brown Pelican. Pictures of a photographic blind, a diamond-backed terrapin, alligator, cotton-mouth moccasin, and a native catching bull frogs are included among the pictures of birds. These photographs, besides being interesting, add to the general information concerning the habitat in which the different birds are found.

Cruising Among the Bird Islands of Hawaii, by Alfred M. Bailey, *Director, Chicago Academy of Sciences*, Distributed by the Society for Visual Education, Chicago (50 pictures; teacher's syllabus).

This picturol traces a cruise among bird islands which extend 1,400 miles northwest of Honolulu. It shows pictures of Neckar Island (two days journey from Honolulu), French Frigate Shoals (three days journey), Midway Island (a beautiful coral atoll almost in the middle of the Pacific—where cable messages are relayed from Honolulu to Nagasaki, Japan) and Laysan Island (850 miles northwest of Honolulu). Pictures of shore lines, vegetation, government stations and dwellings precede the bird pictures and provide a background of information for the study of birds. Most of the pictures were taken on Laysan Island which is considered one of the foremost bird islands of the world. The pictures show the adults, nests, eggs and young of the Laysan Teal, Black-footed Albatross, Christmas Island Shearwater, White-breasted Petrel, Pacific Golden Plover, Blue-faced Booby, Man O'War Bird, White Tern, Hawaiian Tern and Laysan Albatross.

There are several very interesting and unusual pictures near the end of the picturol which show the quaint dance steps of the Laysan Albatross, and Man O'War Birds waylaying a Booby and taking the fish which he has caught away from him. The teacher's syllabus provides detailed and interesting information about each picture.

MATHEMATICS AND GENERAL SCIENCE COOPERATE IN JUNIOR HIGH SCHOOL

Jules H. Fraden and Paul M. Tully
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It has always been a problem for teachers of mathematics to make courses in mathematics functional; that is, to use mathematics in actual life situations. In order to receive best results students should acquire knowledge through self activity, or by direct experience. The experiences should not be heterogenous and unconnected but unified or fused. The emphasis on practical life situations wherever and whenever possible cannot be too greatly stressed.

The second yearbook of mathematics states, "The Metric system should be brought into service several times in these grades (referring to the junior high school), at least until the pupil is reasonably familiar with centimeters, grams, and liters. In this respect we owe it to the pupil and to the public to create a desire for its adoption. The United States should fall into line with the rest of the world in adopting decimal subdivisions of all units. The only difficulty in the way is the attitude of the public. It is the duty of the teacher, through the school, to enlighten the public and so to modify this attitude."

The metric system is difficult for an eighth grade pupil to grasp. Many reasons may be given for this difficulty. The main one being that an American child has not come in contact with these units of measure. We must show the child the functional aspects of the material in order for the child to see its importance.

To best study this unit we believe it is best to bring the mathematics class into the general science room. This procedure makes it necessary for the mathematics and the science teachers to plan the unit together—the result being a tendency to tear down the narrow lines of departmentalization. The general science and the mathematics teachers both help with the work of the unit.

The following is a sample unit that could be utilized in a fused junior high arithmetic—general science course. Suggestions for the fusion of other units may be found in the summary of this paper.

Fused Unit Plan on the Metric System

Group objectives—Mathematics and General Science.

1. To show that the metric system of weights and measures is simpler and more efficient than our present system and that the sooner we begin to use it the better.
2. To show that in the study of scientific subjects, formulas and other mathematical tools are much used.
3. To show that mathematics is a valuable aid to thinking in general science.
4. To show functional applications of the metric system to everyday life.

At this point it would be well to have a general discussion of what students know about the metric system. A pretest on the unit could be given.

Pretest

1. Do you know whether all countries in the world use the same units of measurement?
2. Do you suppose that any country has a better system than our units of measurement? If so, would it pay us to know about it?
3. Would it be better to have fewer units than we now have? Before making your decision note the following list of some of the units now in use: bushels, pecks, barrels, drams, yards, fathoms, inches, grains, miles, pints, mills, feet, and ounces.
4. Would it be better if all countries used the same units of measurement? How many countries use the metric system at present?
5. Do you know whether the metric system which measures in meters, grams and liters, and which is used throughout so much of the world, is used at all in the United States?

The following information may be mimeographed and handed to each student.

Introduction to the Metric System

The essential units of the metric system are given in the table below The values and their prefixes should be memorized. The blanks indicate units not frequently used.

Prefix	Weight	Length	Volume	Value
milli-	mg	mm	ml	.001
centi-	cg	cm	....	.010
		dm	....	.100
deci-	dg	meter	liter	1.000
	gram			
....	....	....	....	....
....	....	....	....	....
....				
kilo-	kg	km	....	1000.0

Metric Equivalents

1 meter.........39.37 inches	1 kilogram....2.2 pounds
1 inch.......... 2.54 centimeters	1 milliliter....1 cubic centimeter
I ounce.........28.35 grams	1 cc pure H_2O
1 liter.......... 1.06 quarts	(at 4°C.....1 gram
	1 kilometer...0.62 mile

Problem Set

1. A 100 m race covers how many yards?
2. Express in American units of measurements the facts of the following newspaper quotation:

Metric system	Subject matter which is common to mathematics and general science		Activities of students and teachers
	Mathematics	General Science	
Length millimeter (mm) centimeter (cm) decimeter (dm) meter kilometer (km) micron	The unit of length is the meter. It is divided into tenths, or decimeters; into hundredths, or centimeters; and into thousandths, or millimeters. Refer to problem set for problems on length.	Air pressure is measured in millimeters or in centimeters of mercury Radio wave lengths are measured in meters. Explain use of microns in the biological sciences.	1. Measure class room in metric units. 2. Make a mercurial barometer. 3. The teacher may discuss the measurement of track and field events in the Olympic games. 4. If near a museum which contains a replica of the platinum bar used as a standard, by all means plan a field trip. 5. Have the students look for references to the metric system in magazines and newspapers. 6. Cooperate with the English teacher—have the pupils write compositions in the English class on the "History of the Metric System." 7. Compare the metric and the United States units. 8. Show the students a Microtome if possible, or show slides which were cut by a Microtome.
Weight milligram (mg) centigram (cg) decigram (dg) gram kilogram (kg)	The unit of weight in the Metric System is the gram. The gram is the weight of one cubic centimeter of distilled water at a temperature of 4°C. Refer to problem set for problems on weight.	Compare the weights of equal volumes of water and milk in the metric system. Show the importance of metric weights in experimental manipulations.	9. Each student should weigh an object first in the British system and then weigh the object in the metric system. 10. Compare grams and pounds.
Volume millimeter (ml) liter (l)	The standard unit of measure of capacity is the liter. One liter equals one cubic decimeter or 1000 cubic centimeters. Refer to problems set for problems on volume.	Show the importance of the use of volume in scientific work.	11. Each student should be given an unknown amount of water and a graduate cylinder. The student will proceed to measure the volume of the unknown quantity of water. 12. Compare the volume of a quart and a liter. Point out the differences. 13. Discuss the advantages of the metric system in general. *Summary and testing.* Summarize Examination

"An airplane, carrying a useful cargo of 4000 kilograms, remained aloft 2 hours and 19 minutes and reached an altitude of 5000 meters."

3. How many millimeters are there in 1 centimeter? In 1 decimeter? In 1 meter? In 1 decameter? In 1 kilometer?
4. Express 1 liter as milliliters.
5. How many liquid quarts are there in 10 liters?
6. Express 20 km as miles.
7. 50 kg equals how many pounds?
8. How many grams are there in a metric ton?
9. Express 1.6 g in decigrams, centigrams, and milligrams.
10. 300 cc of H_2O equals how many grams?

If at the end of the unit little Jerry remarks, "Why don't we use the metric system? It is so much easier to use than our own units of measure," the unit will then be considered a success.

Summary

1. Teachers should give children the opportunities to see: "Arithmetic as a subject, interesting, challenging, practical, and applicable to their everyday surroundings."

2. Teachers should attempt to break down narrow departmentalization by cooperation between faculty members in preparing units whereby common subject matter is stressed.

3. Mathematics should be taught functionally; that is, show actual applications of mathematics to everyday life.

4. Mathematics teachers should have a broader knowledge of other fields such as: science, social studies, and art so as to make mathematical applications to these fields.

5. Many other units in mathematics may be fused with general science. The following are a few examples:

   1. How fast does sound travel?
   2. Measurements of temperature.
   3. Science saves health.

CREATE NEW PERFUMES

Organic chemists at Columbia University have created two new perfumes; one a distinct odor of cedar wood and the other a warm spicy odor of violets, according to Prof. Marston Bogert and O. N. Jitkow in a report to the American Chemical Society.

TOMATOES' VITAMIN C

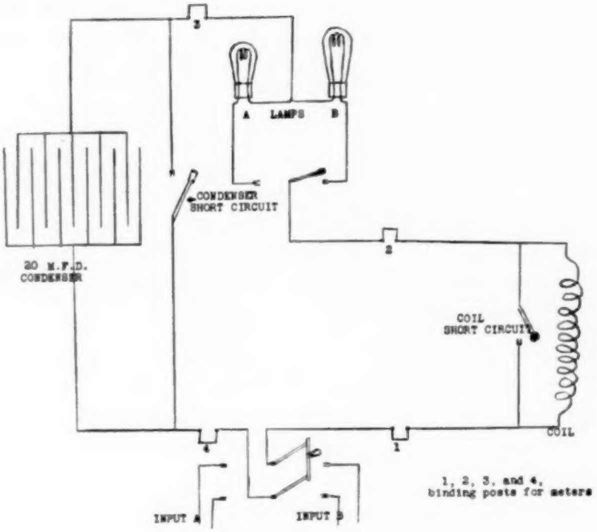
People who peel tomatoes before serving them in salads are cutting off much of the vitamin C content. It is found that the vitamin C in tomatoes is associated with the fast-growing areas where the tomato makes new materials for growth.

AN ELECTRICAL RESONANCE OUTFIT

VERNON SHIPPEE
Orange, California

The construction of this piece of apparatus is simple and cheap. It should be made easily for not more than five to ten dollars. Although it is easy to make, there is no limit to the uses which can be made of it.

Possibly the most expensive part of the whole thing is the condenser. It takes approximately a 20 mfd. condenser. This may be made up of smaller blocks hooked up in parallel. Electrolytics are not satisfactory because A.C. is used mostly. Old



discarded paper condensers in good condition can be picked up sometimes at a radio shop.

The coil is probably the hardest item to make. It takes approximately 3,000 turns of single-cotton-covered, number 18 copper wire. It should be wound on a two-inch, hollow form, ten inches between ends. If a suitable form cannot be found, it can be made out of gummed paper tape. By using a slightly tapered wooden core, the tape can be wet and wound on a paper, covering the wooden core until stiff enough to support the wire. The ends can be made by winding the tape up higher (approxi-

mately half an inch) and trimming it off square. Twelve layers are sufficiently close to the required number of turns of wire. A lathe is very useful in winding the coil, but it can be done by hand. The core for the coil should be made of silicon iron, but, if this is unavailable, a piece of ordinary soft iron is quite satisfactory. It should be long enough to fit entirely in the coil with a little left out at the top. It should fit as snugly as possible inside. The primary for use of the coil as a transformer is made in much the same way as the large coil; only, larger wire (about No. 12) and only one layer is used. If a smaller core is made for this coil, it greatly increases the efficiency of the transformer. The base board for the outfit should be about one by two feet with cleats on the bottom to protect the wiring. The rest of the parts are cheap and are easily bought. There are two lamp sockets, one double-pole, double-throw switch; one single-pole, double-throw switch; two single-pole, single throw switches; and a dozen binding posts. Number 14 rubber covered wire is best for connections.

The diagram may be followed for the wiring. The condenser and coil are both wired to switches which will shunt the current around them if they are not needed in a hookup. The lamp switch must be in on one light or the other for the circuit to be completed. There is no short circuit switch across the lights, for protection against blowing fuses. The circuit is broken in four places by binding posts which are connected by short pieces of wire or are used as connections for meters.

A stand may be mounted on the base to clamp the choke rod in any desired place. Also it is best to put a large covering (a tin box, or some such protection) over the condenser to keep the operator from getting a good stiff jolt.

The outfit gave very good results for resonance on both 110 and 32 volt circuits. By having two lamps of corresponding voltages but of different wattage, results may be gotten from both circuits at once. The 32V. lamp gave best results at 15 watts, while the 110V. lamp was best at 150 watts. The condenser capacity, 17 mfd. was the same for both voltages, and the choke rod was at very nearly the same depth for both voltages. The coil as it was wound has an inductance of 0.9 henry, and with the choke rod fully inserted, an inductance of 13 henrys. The 110V. lamp passed 1.36A. alone, and when the condenser and coil are in resonance, the circuit passes 0.893A. Perfect resonance is obtained by adjusting the choke rod to the position where the

light glows the brightest. The coil has a resistance of 10.6 ohms as measured by the voltmeter-ammeter method.

This outfit also demonstrated the principle of inductance very well. The 110V. lamp glows quite brightly with the condenser out of the circuit, and only the coil and light left in. But, when the choke rod is inserted, the lamp is completely put out.

With the use of the primary described above, the principle of the transformer may also be demonstrated. Our primary just fits inside the induction coil, and has 110 turns of No. 12 single, cotton-covered copper wire. This has hardly any resistance; so it is necessary to use a resistance in the circuit. A carbon compression rheostat is the best for this purpose, because it will pass a large amount of current safely. At 110V. and 15A. input, 0.1A. was the output. Most of the input is taken up in the rheostat since the voltage drop across the coil is very small. With the small core inserted in the primary, the output was increased from 0.51A. to 0.6A. The core may be made of the same material as the choke rod, but so that it just fits inside the primary. As closely as could be noted, the input voltage was between 3V. and 4V., while the output ranged from 67V. to 85V.

The possibilities of this board as a basis of other demonstrations are many. For instance, with the proper frequency, the coil could be used for making a jumping ring, or a cannon shooting aluminum balls. It might also be used for a spot welder by proper experimentation with the current to be used.

FLORAL WONDERS PRODUCED BY CHEMISTRY

Marigolds half a foot across, snapdragons with blossoms of deeper color and sturdier stems, spearmint of a different flavor are among the newest accomplishments in plant breeding made possible by colchicine. These and other plants have been developed at the New York State Agricultural Experiment Station here by a husband-and-wife team of scientists, Drs. Bernhard R. Nebel and Mabel Ruttle Nebel.

The marigolds are perhaps the most spectacular, for their sheer size and brightness of yellow and orange colors. Original breeding stock was the familiar African marigold species. Young seedlings of this species, after treatment with colchicine solution grew up and produced offspring with double the usual number of heredity-bearing chromosomes. Technically such plants are known as tetraploids. Results have varied somewhat from variety to variety.

REASONING PROBLEMS IN MATHEMATICS

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It is proposed here to suggest a type of problem which will appeal to children of the elementary and secondary school age. These might well be called "Problems in Arrangements and Chance." The teacher will find that the samples worked out below, as well as the list which is appended, are real to the pupil and form a part of his experience. By means of these exercises the teacher should be able to instill a lively interest in reasoning itself and at the same time do something toward imparting some of the mental disciplinary values which are transferable to situations in everyday life. Since each problem can be worked out experimentally, at least for small numbers, the pupil will have a definite check on his work and will thus obtain further confidence in his ability to reason. This type of check differs from the usual ones which are merely verifications of mechanical processes. For some unknown reason this material has been relegated by tradition to college algebra, where it is called "Permutations, Combinations and Probability." It seems a pity that the vast majority of our students should be deprived of the benefits that may be derived from the study of this material, especially since the technique needed for the solution of all such problems involves only the elementary operations with whole numbers.

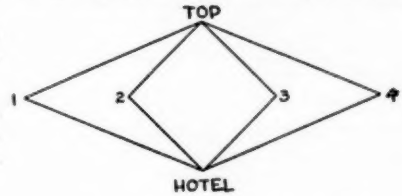
Even teachers of the seventh and eighth grade will find a number of the problems given below suitable for their pupils, and this material might well be a partial substitute for the so-called "real and practical" problems on banking, stocks, bonds and mortgages. After all, boys and girls between the ages of eleven and fourteen cannot be vitally interested in this business jargon nor do they see such reality and usefulness in these subjects, as so many curriculum makers would have us believe.

The specific problems given and the methods of solving them are merely suggestions which should be varied according to the interests and maturity of the pupils.

Problem 1. There are four trails to the top of a mountain. A tourist starting from his hotel at the foot of the mountain wishes to go to the top and return to the hotel. How many choices does he have for such an excursion, if he does not use the same trail going and returning?

Solution. If the tourist goes up by trail (1), he may return by trails (2),

(3) or (4). Thus he has three choices of going up by trail (1) and returning by a different trail.



Similarly, there are three ways of going up by trail (2) and returning by a different trail, etc.

Thus, the total number of trails will be 4×3 or 12. Diagrammatically, these 12 paths may be indicated as follows:

up	*down*	*up*	*down*	*up*	*down*	*up*	*down*
(1)	(2)	(2)	(1)	(3)	(1)	(4)	(1)
(1)	(3)	(2)	(3)	(3)	(2)	(4)	(2)
(1)	(4)	(2)	(4)	(3)	(4)	(4)	(3)

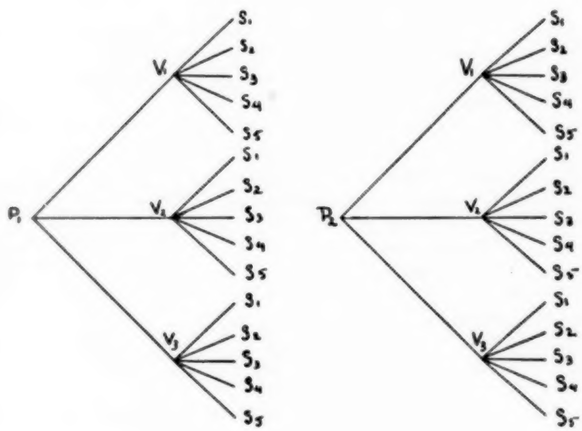
Note. In this and all the other problems given below the teacher should not only encourage but insist that the student write down all the possibilities that arise but this should be done with small numbers so that the actual labor does not become too excessive. He should observe the reasoning involved and apply the same reasoning to similar problems with larger numbers.

Problem 2. The eighth grade class is to elect a president, a vice-president and a secretary. There are two candidates for the presidency, three for the vice-presidency, and five for the secretaryship. How many different slates can be formed?

Solution. Let the presidential candidates be denoted by P_1, and P_2; the candidates for vice-president by V_1, V_2, V_3; and the candidates for secretary by S_1, S_2, S_3, S_4, S_5.

With P_1 we have a choice of V_1, V_2, V_3, and with P_2 we have a choice of V_1, V_2, V_3. Thus we have 2×3 or 6 possibilities for president and vice-president alone. With each one of these six choices there are five possible secretaries that could be chosen, making a total of 6×5 or 30 different slates.

The following is a complete list of the possibilities:



Problem 3. How many numbers each consisting of three distinct digits, may be formed from the digits 1, 2, 3, 4?

Solution.

Hundreds	Tens	Units
four	three	two

For the hundreds place of our three digit number, we have four choices, since we may use any of the digits 1, 2, 3, or 4. If we had used 1 as the hundreds digit, then for the tens digit, we would be forced to use 2, 3, or 4, since the digits are stipulated to be distinct. A similar remark applies when 2, 3 or 4 are used as the hundreds digit. We see then that there are 4×3 or 12 ways of filling the hundreds and tens places. For each of these 12 ways there still remain two ways of filling the units place (since we have already used up two of the four available digits). Thus, there are altogether 12×2 or 24 different numbers, consisting of three distinct digits, which can be formed from the numbers 1, 2, 3, 4. They are

123✓	213✓	312✓	412×
124×	214×	314□	413□
132✓	231✓	321✓	421×
134□	234○	324○	423○
142×	241×	341□	431□
143□	243○	342○	432○

Problem 4. The seventh grade is to select three council members out of four available candidates. How many different councils may be chosen?

Solution. Let us denote the candidates by the numbers 1, 2, 3, 4. By actual count we see that there are only four possible councils consisting of the groups (1, 2, 3), (1, 2, 4), (1, 3, 4) and (2, 3, 4).

To solve this problem by reasoning we must first observe that it is similar to problem 3 just solved with one important difference. While in the preceding problem every change in the order of the three digits gave rise to a new number, in this problem the only thing that matters is who the three individuals are and not the order in which they were elected or grouped. Hence, the answer to the present problem may be obtained from that of problem 3 by dividing it by the number of ways in which three numbers may be arranged among themselves. But by the same reasoning as that employed in problem 3, three numbers may be arranged in $3\times2\times1$ or 6 different ways. Thus the answer to problem 4, found by dividing 24 by 6 is 4. The markings which follow the arrangements in problem 3 indicate which groups are re-arrangements of each other.

Note. It should be pointed out that whenever one is required to find the number of committees, the problem should be analyzed as two problems of arrangement. Thus, if one wishes to find the number of committees of four that could be chosen from seven candidates, first find the number of ways in which seven numbers may be arranged four at a time and then divide this number by the number of arrangements of the four numbers among themselves. Using the reasoning of problem 3, there are seven choices for the first place, six for the second, five for the third and four for the fourth place, so that there are $7\times6\times5\times4$ possibilities of arranging four numbers out of seven. Similarly, there are $4\times3\times2\times1$ ways of arranging four numbers among themselves. Hence, there are

$$\frac{7\times6\times5\times4}{4\times3\times2\times1}=35 \text{ committees.}$$

Problem 5. Two coins are tossed. In how many different ways may they fall?

Solution. There are four possibilities since with the head of the first coin the head or tail of the second coin may appear, and likewise with the tail of the first coin the head or tail of the second coin may appear.

If, instead of two coins three coins are tossed, there would be eight possibilities altogether. For, with each of the four possibilities given for the first two coins, the third coin could fall either head or tail. The various possibilities are here given.

First	Second	Third	First	Second	Third
H	*H*	*H*	*H*	*H*	*T*
H	*T*	*H*	*H*	*T*	*T*
T	*H*	*H*	*T*	*H*	*T*
T	*T*	*H*	*T*	*T*	*T*

Problem 6. If two dice are rolled, in how many ways may a sum of 10 appear?

Solution. Since each die has the numbers 1 to 6 on its faces, the sum of 10 may be obtained with a 6 on the first die and a 4 on the second, a 4 on the first die and a 6 on the second, and finally with a 5 on each die, so that the sum 10 may be obtained in three ways.

Problem 7. If two dice are thrown what is the chance that a 10 will appear?

Solution. Since any one of the numbers from 1 to 6 may appear on the first die and any one of the numbers from 1 to 6 may appear independently on the second die, there are then 36 different ways in which the two dice may turn up. However, the number of ways in which a sum of 10 may turn up has already been found in the preceding problem, to be three. Since there are three favorable ways for the appearance of a 10, and there are altogether 36 ways in which two dice may fall, the chance for the appearance of a 10 is 3 in 36 or 1 in 12.

Problem 8. If three coins are tossed, what is the chance that two heads will appear?

Solution. It is plain that this is precisely the problem of choosing a committee of two from three candidates, which may be done in three ways $(3\times 2/2\times 1)$, as shown in the diagram.

Coin 1	Coin 2	Coin 3
H	*H*	*T*
H	*T*	*H*
T	*H*	*H*

Since by Problem 5 there are a total of eight ways in which three coins may fall, the chance of two heads appearing will be three in eight.

Problem 9. There are six basketball teams in a school league. If each team plays four games with each one of the other teams, how many games will be played altogether during the season?

Solution. Call the teams A, B, C, D, E, F. Team A plays with five other teams and hence plays 5×4 or 20 games. Team B plays with four other teams (since this team has already played with team A) and hence plays 4×4 or 16 games; etc. Thus the total number of games played will be $20+16+12+8+4=60$.

It is of interest to solve this same problem by noting that team A plays four games with each of the five other teams so that team A plays a total of 20 games. What is true of team A is also true of every one of the five other teams, so that in this way it appears that a total of 6×20 or 120 games are played. We must remember however that team A playing with team B, for example, is the same as team B playing with team A, so that the number 120 is actually twice the total number of games played.

This problem may also be interpreted as a problem of choosing a committee of two from six candidates ($6\times 5/2\times 1=15$) and this result when multiplied by 4 (the number of games played by each team) gives us the answer.

For the case of n teams playing r games the first method gives us

$$(n-1)r+(n-2)r+\cdots+1\cdot r.$$

The second method gives us

$$\frac{n(n-1)}{2}\cdot r.$$

Since these two results must be the same, we obtain the well known formula

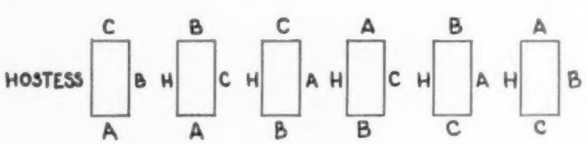
$$1+2+\cdots+(n-1)=n(n-1)/2.$$

Problem 10. Two thousand tickets are issued for a lottery in which there are four prizes of \$100, ten prizes of \$50, and twenty of \$10. Would it be worth while to invest \$2 for a ticket in the hope of winning one of the 34 prizes?

Solution. The total amount of the prizes offered is $4\times 100+10\times 50+20\times 10$ or \$1100. But since there are 2000 tickets, the expectation of winning a prize is 1/2000 of the value of the prize money, or 55¢, so that it would be bad business to invest \$2 for a ticket.

Problem 11. A girl invites three friends to a luncheon. In how many different ways may the four girls be seated around a table?

Solution. After the hostess seats herself, the first guest may be seated in any one of three chairs, and after that the second may be seated in any one of the two remaining chairs, so that there are 3×2 ways of seating the first two friends. But there is only one chair remaining for the third friend, so that there are a total of six ways for four girls to seat themselves in a circular order.



Note. If the four girls were arranged in a row, there would be 24 ($4\times 3\times 2\times 1$) ways of seating them.

Problem 12. How many distinct arrangements are there of the letters *a*, *bbb*, *cc* taken six at a time?

Solution. If the letters had all been different, there would be $6\times 5\times 4\times 3\times 2\times 1=720$ arrangements possible, but in view of the fact that there are three *b*'s these 720 arrangements would have to be divided by the number of ways in which three things may be arranged among themselves; otherwise the arrangements would not be distinct. Finally, this last answer must be divided by the number of ways in which the two *c*'s must be arranged among themselves, Thus our final answer will be

$$\frac{6\times 5\times 4\times 3\times 2\times 1}{3\times 2\times 1\times 2\times 1}=60.$$

Problem 13. A council of five members is to be chosen, three of which are to be girls and two boys. If there are six girl candidates and four boy candidates, in how many different ways may the council be chosen?

Solution. Since there are six girls available, the first successful girl candidate may be any one of the six; the second, any one of the remaining five; and the third, any one of the remaining four. We must keep in mind however that the order in which the three girls are chosen is immaterial, and hence, the number of committees will be $6\times5\times4/(3\times2\times1)$, or 20.

Similarly, for the boys, the number of choices will be $4\times3/(2\times1)$ or 6. But with each of the 20 choices of the girls there may be associated any one of the six choices of the boys; altogether there are 20×6 or 120 possible councils that may be formed.

Supplementary Problems

1. There are three bridges leading from Cincinnati to Kentucky across the Ohio River. In how many ways may one go from Cincinnati to Kentucky and return (a) not using the same bridge on the return journey as he did in crossing; and (b) using any bridge going and coming? Write out all the possibilities. Ans. (a) 6; (b) 9.
2. A boy has three suits and two pairs of shoes. In how many ways may he dress, assuming that he may wear each pair of shoes with every suit? Ans. 6.
3. A club has 10 boys and 8 girls. In how many ways may the club select its officers, if the president is to be a boy and the vice-president is to be a girl? Ans. 80.
4. A girl, in making out her program, has her choice of two teachers in arithmetic, three in history and four in English. In how many ways may she fill out her program.? Ans. 24.
5. A girl has four dresses, two hats and three pairs of shoes. Assuming that they all match, how many different outfits does she have? Ans. 24.
6. A girl, in making a dress, has a choice of three different materials, five colors, two sleeve lengths and four different neck styles. How many different dresses could be made? Ans. 120.
7. In a small high school there are 252 boys and 214 girls. A boy and a girl are to be selected to represent their school in an oratorical contest. If eight boys and six girls are eligible, in how many ways may they be chosen? Ans. 48.
8. In choosing a meal in a restaurant, a man may select from two soups, five meats, four vegetables, two salads, six desserts and three drinks. If he has a choice of one of each, how many distinct menus may he order? Ans. 1440.
9. A girl wishing to make sandwiches for a party has lettuce, ham and cheese available. How many different kinds of sandwiches can she make if she uses (a) only one of the ingredients in a sandwich? (b) two in a sandwich? (c) all three in a sandwich? Ans. (2) 3; (b) 3; (c) 1.
10. If there are three railway lines from Chicago to St. Paul and four lines from St. Paul to Seattle, in how many ways may one go by rail from Chicago to Seattle, via St. Paul, and return without going over the same line twice? Ans. 72
11. In how many ways may three boys be seated in a row of five seats? Ans. 60.
12. In how many ways may five girls be seated in a row of five seats? Ans. 120.
13. From the numbers 1, 2, . . . , 9 how many two digit numbers may be formed (a) if the digits are to be distinct? (b) if the digits need not be distinct? Ans. (a) 72; (b) 81.
14. How many ways are there of posting two letters in four boxes (a) if both letters may not be put in the same box? (b) if there is no such restriction? Ans. (a) 12; (b) 16.

15. Given five flags of different colors, how many signals may be made by raising two of them (a) if they are raised at the same time? (b) one after the other? Ans. (a) 20; (b) 25.

Hint. Two flags of different colors may be used for two distinct signals, depending on the positions of the flags.

16. How many signals may be made by running up one, two or three flags on a rope, if five flags of different colors are available? Ans. 85.

17. How many signals may be made by hoisting three flags in a row, given seven flags of different colors? Ans. 210.

18. In how many ways may a baseball manager arrange (a) his four infielders, if each can play any position in the infield; (b) his three outfielders? (c) What is the total number of teams that could be formed? Ans. (a) 24; (b) 6; (c) 144.

19. How often can six ball players take positions on a bench without sitting twice in the same order? Ans. 720.

20. In how many ways may nine players be placed on a baseball team, if only three can pitch, only two others can catch and the other seven players may play any position other than pitching or catching? Ans. $3\times2\times7\times6\times5\times4\times3\times2\times1$.

21. How many two digit numbers may be formed from 0, 1, . . . , 9 (a) if repetitions are allowed? (b) if repetitions are not allowed? Ans. (a) 90; (b) 81.

Hint. The 0 cannot be used as a first digit.

22. How many two digit numbers ending in an even digit may be formed from the numbers 0, 1, . . . , 9 (a) if repetitions are allowed? (b) if repetitions are not allowed? Ans. (a) 45; (b) 41.

23. How many three digit numbers may be formed from the digits 1, 2, 3, 4, 5, (a) if the digits in each number are distinct? (b) if repetitions are allowed? Ans. (a) 60; (b) 125.

24. How many odd three digit numbers may be formed from the digits 1, 2, 3, 4, 5, (a) if the digits are to be distinct, (b) if repetitions are allowed? Ans. (a) 36; (b) 75.

25. In a certain county the automobile license plates are made up by choosing three digits from the numbers 0, 1, 2, . . . , 9, followed by two letters from the alphabet. How many such plates may be formed? Ans. 676,000.

26. If four dice are rolled simultaneously in how many different ways may they turn up? Ans. 1296.

27. In how many ways may five coins fall if they are tossed simultaneously? Write out the possibilities and thus check your reasoning. Ans. 32.

28. By how many straight lines may ten points be joined, if no three points are on the same straight line? Ans. 45.

29. Given ten points, no three of which are on the same straight line. How many triangles can be formed using these points as vertices? Ans. 120.

30. In the National League there are eight teams and each team plays 22 games with each of the other seven teams. What is the total number of games scheduled during the season? Ans. 616.

31. A man and his wife invite four couples to their home. If none of the invited couples know each other (it is understood that every couple knows the host and hostess), how many separate introductions will have to be made? Ans. 24.

32. In a certain school room the boys sit on one side of the room and the girls on the other. In how many ways may a group of four new boys and three new girls be seated, if there are five vacant seats on each side? Ans. 7200.

33. In how many ways may four French books, three German books and two Latin books be arranged on a shelf so that all the books in each language may be together? Ans. 1728.

Hint. First consider the French, German and Latin books as three single units and determine how many arrangements three are of these three units on the shelf. Next consider the possible arrangements of the four different French books among themselves. Do this also for the German and Latin books.

34. In how many ways may three boys and three girls be arranged in six seats (a) if the girls must sit together and the boys must sit together? (b) if the girls and boys sit in alternate seats? Ans. (a) 72; (b) 72.

35. From four teachers and seven pupils, in how many ways may a committee of five be chosen so as (a) to include exactly one teacher and (b) to include at least one teacher? Ans. (a) 140; (b) 441.

36. In how many ways can six men be divided up into three committees of two men each, provided that no man serves on more than one committee? Ans. 90.

37. In how many ways may a pair be selected from 10 tennis players? Ans. 45.

38. How many arrangements can be made of the letters in the word "peep," using all the letters? Ans. 6.

39. How many arrangements can be made of the letters of the word "success," using all the letters? Ans. 420.

40. How many arrangements can be made of the letters in the word "Mississippi," using all the letters? Ans. 34,650.

41. In how many different ways may four keys be arranged on a ring? Ans. 6.

42. In how many ways may the batting order of a baseball nine be arranged with the three best batters consecutive?

Ans. $3 \times 2 \times 1 \times 7 \times 6 \times 5 \times 4 \times 3 \times 2 \times 1$.

43. In how many ways may four boys and two girls be seated in a row of six seats, with the girls sitting together? Ans. 240.

44. A bag contains five red balls and three black balls, all of the same size. If a ball is drawn without looking, what is the chance that (a) it will be red and (b) that it will be black? Ans. (a) 5 in 8; (b) 3 in 8.

45. (a) What is the chance of drawing an ace from a deck of 52 cards? (b) of drawing any diamond? (c) of drawing an honor, that is, an ace, a king, a queen, a jack or a ten? Ans. (a) 1 in 13; (b) 1 in 4; (c) 5 in 13.

46. A bag contains 100 envelopes 40 of which each contain a one dollar bill, and the others are empty. What is the most I should pay for the chance of drawing a prize? Ans. 40 cents.

47. In a certain town it is found that four out of every thousand houses are destroyed annually by fire. What premium should an insurance company charge for insuring a house worth \$8000 against a total loss? Allow 25¢ per thousand dollars for overhead. Ans. \$34.

48. Find the chance of throwing a total of 2, 3, 4, . . . , 12, with two dice. Ans. 1, 2, 3, 4, 5, 6, 5, 4, 3, 2, 1 in 36.

49. In a single throw with two dice, what is the chance of throwing a (a) a total of less than 6? (b) a total of more than 6? (c) a total of exactly 6? Ans. (a) 10 in 36; (b) 21 in 36; (c) 5 in 36.

50. What is the chance of throwing "heads" four times in succession when tossing a coin? Ans. 1 in 16.

51. Six coins are tossed simultaneously, what is the chance that (a) exactly three heads and 3 tails will appear? (b) that they will all be tails? Ans. (a) 5 in 16; (b) 1 in 64.

52. From a bag containing three red balls and seven black balls, two

balls are drawn at the same time. What is the chance that (a) they are both red? (b) they are both black? (c) one red and one black?

Ans. (a) 1 in 15; (b) 7 in 15; (c) 7 in 15.

53. Find the chance of drawing two red balls in succession from a bag containing four red balls and three blue balls if (a) the ball drawn is replaced before the next draw and (b) if it is not replaced.

Ans. (a) 16 in 49; (b) 2 in 7.

54. *A* and *B* draw cards marked from 1 to 10 for a prize of $6, the prize to be taken by the one who draws the higher number. If *A* has drawn a 7, what is it worth to *B* to draw a card? Ans. $2.

55. Six men *A*, *B*, *C*, *D*, *E*, *F*, take seats at random in a row of six seats. Find the chance that *A* and *B* will sit side by side. Ans. 1 in 3.

LABORATORY SCIENCE

Leonard A. Ford
State Teachers College, Mankato, Minnesota

Leaders in the field of education and curriculum planning are bringing about a reorganization of the high school course of study. The distinctive feature of most of these new programs involves a shift away from subject matter emphasis. Subjects which are greatly affected by this new trend are the "pure" sciences; chemistry, physics and biology. Attempts are being made everywhere to change the nature of these subjects or even remove them from the curriculum. Words such as vitalize, integrate, socialize and functionalize are frequently used to designate this new trend in science education.

The phase of science teaching which has undergone the greatest reorganization is the student laboratory work. The tendency seems to be to do away with this part of science teaching. Laboratories have been a constant source of irritation to some administrators because they are expensive and because the double laboratory periods upset an otherwise smooth running curriculum. Further, the charge is made that the laboratory serves to prepare for further college work in this field and few students do on to college. The techniques learned in laboratory manipulation serve no useful purpose.

The new science, sometimes called 12th year science, physical science, biological or integrated science is usually set up without laboratory work. Demonstrations, moving pictures and outside readings from current magazines and books have largely replaced the more expensive, time consuming laboratory work.

To state that there is no value in the new type course without laboratory is certainly not justified. But what are its objectives?

Does it accomplish them? Is there any evidence to show that natural science without laboratory work is accomplishing objectives set out by the curricula makers? To teach science is one thing and to teach about science is another.

We live in a physical world; a world of material objects that we must touch, smell, hear and see. Laboratory work in the pure sciences gives us a contact with that world. While demonstrations by the instructor are helpful they can never replace student laboratory work. Most students are too far away from the apparatus to see it clearly. Impressions gained by a student watching the instructor are never as clear as when he finds out something for himself. Visual education with its moving pictures, photographs and drawings can show things in only two dimensions. They can never replace the concrete experience obtained by the student who can handle or manipulate some physical object placed before him and see it in three dimensions.

The modern world is alive with physical transformations of time and space, of chemical and biological changes. Shall we deprive the student of an opportunity to obtain first-hand personal knowledge of that world?

Laboratory work as it has been taught in most high schools needs to undergo a rather complete transformation. Many of the time-honored experiments should be discarded and replaced with others which teach scientific principles and at the same time give the student an understanding of the world in which he lives.

Science instructors need to inform themselves of the trends in modern education. Hiding in their laboratories until the storm passes by, will avail them nothing. They may find their laboratories transformed into social science classrooms.

The science instructor needs to attend professional education meetings, read current literature on science teaching and education in general. Knowledge of subject matter is not enough. He needs to understand the viewpoint of the professional educator as well.

The objective laboratory sciences will be secure in the curriculum only when the science instructors can justify their existence.

When you change address be sure to notify Business Manager W. F. Roecker, 3319 N. 14th Street, Milwaukee, Wis.

THE SUBJECT MATTER OF SCIENCE

PHILIP B. SHARPE
Greenwich High School, Greenwich, New York

If it be granted that science should be conceived and taught as a "tool" or skill subject, having for its purpose the developing of scientific traits rather than the mere stowing of scientific information, it is granted that science should be the main part of a fourth "R," Research, a core subject. And we must choose the necessary subject matter of science by a new criterion or standard.

In the other skill subjects we feel quite properly that the subject matter on which we practice is relatively unimportant as compared with the practice itself and the skills developed thereby. In reading it matters little what is read provided that it well serves the purpose of developing skill in reading. We feel the same way about the subject matter of "'riting" and "'rithmetic." Similarly in research, the skill required and developed should be regarded as the important thing, not the information memorized. Why should informational value hold the predominating place it does in the selection of subject matter for science courses?

It may be said at once in explanation that science is a new subject in the schools, as compared with the three "R's" and that it is reasonable to suppose that we have not yet learned to teach it properly or to test the teaching effectively. Also it may be said that most people know something about the wonderful discoveries of science but nothing about the methods and traits by which those things were discovered. Consequently we are apt to think that we are getting down to the roots of science in emphasizing scientific principles; consequently we do not recognize the true nature of science and how it should be taught, even when it is shown to us by the precept and example of the great Agassiz; consequently we fall easy victims to several old but rather subtle confusions:—

1. The main practical value of research lies in the useful information to be gained by its use. Therefore the information is important.—But is that not true of the other skill subjects as well? While much of the practical value of reading, 'riting, and 'rithmetic comes from the usefulness of the information produced or disseminated by their use, that fact really indicates that these arts are basic to the information subjects, not that

they are themselves information subjects. The information subjects, on the other hand, are essentially records which must be both produced and spread by means of the skill subjects. That is precisely why the skill subjects have such value. The skill subjects, if taught in such a way as to develop skills rather than to impart information, open the doors to unlimited knowledge.

2. The student necessarily has a reverse point of view. His myopic attention is focused naturally enough on the subject matter. To him the skill is the means to the end of solving the chosen problem, as it should be. But for that very reason his reading matter, essay topics, mathematical and research problems, should be selected for their significance to him, not for their adult informational value. We know that he will read more diligently and profitably, and thus develop more reading skill if he works with *The Reader's Digest* than if he be set at Burk's "Speech on Conciliation with America"; he will develop more skill while writing an exposition of six man football than on "Intimations of Immortality"; he might better figure the compound interest on his college fund than the one about the man who invested one hundred thousand dollars in something or other; he will try harder to find out why a pitched ball curves than to know the exact effect of temperature changes on the speed of sound. It is not claimed that these topics have more informational value in the long run, although that may be possible too; it is claimed that they will develop more skill, and that skill is the most important thing in the skill subjects.

3. The atmosphere of the classroom also promotes this confusion. The teacher necessarily shows a high regard for truth and correct answers and solutions. But back of it all, he should have a viewpoint above and beyond that of the pupils. While the immediate and in a sense, the sole object in reading, 'riting, 'rithmetic, and research seems to be the correct solving of originals of various sorts, the wise teacher will care very little about the correct answers in themselves, which he probably knows in advance, but he understands and quietly utilizes the immediacy of the pupils' interests to develop a permanent *problem-solving ability*.

4. Traces of the old conception of mental discipline probably still linger in our minds, and no doubt, there is great value in the ability to take one's mind by the scruff of its neck, so to speak, and hold it to its appointed task. There is efficiency in

being able to do this on occasions that do not excite the whole organism. However, any difficult task requires concentration, and problem-solving and all that it implies, no matter how interesting the goal, is for most minds both a more severe discipline than mere memorizing and a more badly needed ability.

5. The idea of killing two birds with one stone appeals to our sense of getting something for nothing, but anyone who has tried it a few times knows that one is more apt to miss them both. Now it is possible, even in these days of radios, movies, etc., to load the subject matter of skill subjects with some information that is more useful from an adult point of view than from the point of view of the child. However, the loading should be done with much skillful forbearance lest we kill the interest. We must never lose sight of the fact that *kindling interest, hence effort, hence skill* is the psychological formula for teaching skill subjects. We must never sacrifice the developing of skill in favor of imparting dry information that will all the more likely be cheerfully forgotten. There is great danger of attempting too much and losing both the greater and the lesser or fictitious benefit.

The criterion for the selection of subject matter in science, as in the other skill subjects, should be that it be of sufficient difficulty and of sufficient immediate significance to the pupils to stimulate the greatest problem-solving endeavors. These would be the pupils' own real problems, for the most part.

SAWMILL WASTE NEW SOURCE OF PAPER PULP

Many tons of newsprint can be made from the waste at spruce sawmills, which according to the Forest Products Laboratories of the Department of Mines and Resources at Ottawa, amounts annually in eastern Canada to some 440,000 cords of sound wood, usually destroyed in refuse burners because of lack of markets for such materials.

The forestry specialists estimate that annually in eastern Canada alone, spruce sawmills could reclaim approximately $3,000,000 by sending such refuse from the mills to the pulp mills in the form of pulp chips.

With Scandinavian newsprint sources cut off for many North American newspapers, the need for more Canadian newsprint rises, and reclaiming of sawmill waste will increase.

The more general use of this waste material for the manufacture of chemical pulp would benefit the pulp mills by conserving raw materials, and tend to reduce operating costs of the sawmills which now have to add the cost of disposing waste to lumber costs. So far the use of sawmill waste for chemical pulp has been very limited, but as a result of investigations carried out last year efforts are being made to encourage sawmills and pulp mills to cooperate in wide-scale development of this outlet of waste material. Investigation shows that even the most efficient sawmill usually finds it necessary to burn a considerable quantity of wood.

EASTERN ASSOCIATION OF PHYSICS TEACHERS

One Hundred Forty-Fourth Meeting

TUFTS COLLEGE

Medford, Massachusetts

March 16, 1940

PROGRAM

9:45 Meeting of the Executive Committee.
10:00 Business Meeting.
10:15 Greetings: President Leonard Carmichael.
10:30 Address and Demonstration: "Applications of Electricity and Sound to Radio."
Professor J. R. Harrison
(Demonstrations by Mr. Hammond and Mr. Stevens.)
11:30 Report of Committees.
New Books and Magazine Literature,
Mr. Richard Porter-Boyer, Chairman.
New Apparatus
Dr. Andrew Longacre, Chairman.
12:00 Some Useful Ideas for Physics Teachers.
Mr. Fred R. Miller, Boston English High School.
Mr. Ralph H. Houser, Roxbury Latin School.
Mr. Charles B. Harrington, Newton High School.
1:00 Luncheon, Stratton Hall.
2:30 Address and Demonstration: "New Light Sources for Lecture and Laboratory."
Dr. Richard Tousey.
Address and Demonstration: "Lecture Demonstrations in Mechanics."
Professor F. W. Pote.

Business Meeting

Three were elective to active membership:
Winston M. Gottschalk, St. Mark's School, Southborough, Mass.
G. E. Leffingwell, Lakewood High School, Lakewood, N.J.
Leonard O. Merrill, Boston Trade School, Roxbury, Mass.
William W. Kellogg, Brooks School, North Andover, Mass., was elected to associate membership.

Report of the Committee on New Apparatus

Dr. Andrew Longacre, Chairman.

Mr. Hollis D. Hatch demonstrated a stainless steel mirror for plane mirror experiments. The mirror is about $6'' \times 2''$ with one end bent back so that it stands up without the aid of a block or other support. This eliminates difficulties met with in glass mirrors due to the thickness of the glass, and gives better results than those obtained with the glass ones.

Mr. Elbert P. Little demonstrated a novel magnetic "motor." A disc of lucite, mounted on low friction bearings, had a strip of metal, with a low Curie point, waxed to its circumference. The metal strip ran between the jaws of a small alnico magnet which induced a magnetized region in the strip. A short Nichrome wire, heated by three dry cells and mounted close to the metal strip just above the magnet, demagnetized one half of the

magnetized region, allowing the other half to be drawn into the jaws of the magnet and to rotate the disc.

Science Demonstration Aids.

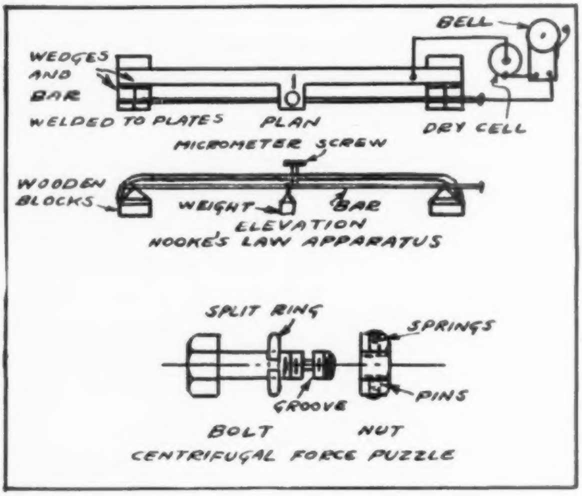
George W. Seaburg

Hooke's law for the bending of beams can be demonstrated by the apparatus shown in the diagram. It was constructed by boys in our school shop. While the principle is not new, this apparatus has some advantages over devices commonly used:—

(1) It is made in one unit which eliminates the necessity of having to assemble several parts.

(2) It can be placed on the edge of the table without using clamps.

(3) The knife-edge supports are recessed so that the rods will not roll off.



When dealing with centrifugal force, this puzzle will help to stimulate interest. The puzzle consists of a nut and bolt on which is placed a split ring. It is impossible to remove the ring as the nut is locked by pins. By spinning the nut, these pins, which are set in a groove fly out due to centrifugal force and permit the removal of the split ring.

The burglar alarm was submitted to me by one of my pupils as his science project. It consists of a box containing a battery; on the box is mounted a loud buzzer and a light bulb. This box is placed behind a closed door and is knocked over when the door is opened. A contact on the outside of the box is closed which causes the buzzer and the light to operate. The burglar is frightened by the noise and the flash, and the household is awakened.

An Anemometer was shown by Mr. John L. Clark. A vacuum cleaner motor with the windings of the field coil removed and a permanent magnet substituted. It was calibrated by mounting it on a $2'' \times 4''$ on an auto and running the car up and down the street. The error was within two miles per hour. Three cups were used to make it more responsive, as four cups produced a less powerful device in low speeds.

Dr. Andrew Longacre demonstrated two pieces of apparatus which he described as follows: The high-pitched note of a Galton whistle usually goes over to a "whish" of air near the upper limit of audition. This has always seemed to interfere with a convincing demonstration of that upper limit. Somewhere, sometime or other, I read of cutting lengths of steel rods so that, acting as a xylophone, they would demonstrate the same phenomenon. The rods were cut from $\frac{3}{8}''$ cold-rolled stock, and a small hole was drilled through each, .224 of its length from one end. The lengths chosen started at about 1.5″, and each was about .25″ longer than the preceding one, up to a length of about 3.5″. Two pieces of wood, $7'' \times 1'' \times .5''$ were then sharpened along an edge and glued to a base board so as to make a V with the sharpened edge upwards. A piece of cord was glued along each edge, and then the steel rods were tacked to this edge by thin finishing nails through the small holes at the nodes. A small wooden hammer made from dowelling serves admirably to excite the bars. The lower frequencies ring out clearly. However, with the higher frequencies, all that one hears is the dull, quickly damped rap of the hammer.

The second apparatus is one that I described in SCHOOL SCIENCE AND MATHEMATICS five years ago, but have never shown to this organization. Essentially it is a lecture table photometer. Two electric lights, housed in black boxes save for a circular opening on one side serve as sources. The comparison device is a 45 degree plaster of Paris prism with the 90 degree edge vertical and towards the audience. Each lamp illuminates one of the faces. At equal distances the vertical edge is lost to view.

Using this photometer it is quite easy to demonstrate the inverse square law. An adjustable shutter is made from two butterfly-shaped cards, each having two 90 degree opaque segments oppositely spaced. This is mounted on a shaft so as to intercept the light from one of the lamps illuminating the plaster of Paris prism. When the shutter is at rest and turned so that the opening lets the light reach the prism, both lamps are equidistant from the prism. When the shutter is rotated at a relatively high speed, the intensity from that side is reduced. For example, with the shutter adjusted for two 45 degree openings, a total of only one fourth of the light is transmitted. To obtain uniform illumination of the prism it is necessary to remove the other lamp to twice its former distance. Actually the device has been used to verify the inverse square law as a laboratory exercise, obtaining a straight line graph between the angle of the opening and the distance squared. The students seem to have no difficulty in understanding that the intensity of illumination is proportional to the opening of the shutter.

A variation in the old experiment of the density of a wooden block was suggested by Mr. Fred R. Miller, and samples of the blocks which he uses were shown. With wooden blocks the density is always less than one. The average boy appreciates the meaning of density better if the object used has sometimes a density greater than one.

The blocks used were of brass, copper, iron, and aluminum, $1\frac{3}{4} \times 1\frac{1}{2} \times 1\frac{1}{4}$ inches in size. By ordering them made in inches, fractions of a millimeter are introduced which aids in the teaching of significant figures. The corners of metal blocks, with the possible exception of the aluminum ones, stay sharp. Three sides of the blocks were filed down so that they slant just a little (± 1 mm) to give a reason for making four measurements and getting the average. By using four kinds of metals each of four pupils at a table get different results.

A Suggestion for Specific Heat

If equal weights of hot and cold water are mixed the final temperature comes halfway between the two initial temperatures except for a slight error due to absorption by the dish.

If mercury at 90° is poured into cold water the final temperature is not at the center, the water rising perhaps 3° while the mercury drops 80–90° in temperature. Dull boys do not get the meaning of this, but by reversing this, using hot water, the result is in terms of absorption of heat by the mercury, and they appear to understand it better.

Mr. Miller also suggested changing Fahrenheit to Centigrade and the opposite by the −40 method, as simpler for pupils to understand. Starting from −40, common to both scales, to change either way, one has only to add 40, multiply by the appropriate constant, and subtract 40.

Mr. Ralph H. Houser showed an apparatus for water pressure experiments, consisting of a burette-like tube about one meter long attached to a support. The bottom of the tube connected with a thistle tube with a U-bend so that the thistle faced upward. This was covered with a rubber diaphragm upon which rested a flat projection about three inches from the fulcrum of a light wooden third-class lever. As liquid is poured into the burette tube, the motion of the diaphragm is magnified by the lever, and indicated on a scale at the right.

WHY THE DECREASE IN PHYSICS ENROLLMENT IN SECONDARY SCHOOLS AND WHAT CAN WE DO ABOUT IT?

CHARLES B. HARRINGTON

Head Science Department, Newton High School

We may approach this problem hopefully, because of the fact that the decline in physics is not quite universal. There are some schools in which there is an increasing enrollment. A comparative study of varying conditions in the two groups of schools should offer helpful suggestions. What can be done in one school should be done in others under equally favorable conditions.

There are at least *eight* contributing factors which we may well consider, each of which may play a vital part in the status of physics in any school. These factors are so closely related and interdependent that it will be impossible to consider them entirely separately or in any order of importance. These factors are:—

1. Time allotment in school program
2. The objectives of our courses
3. Content of courses
4. Interest factor
5. Arrangement or sequence of topics
6. Mathematical problems
7. Methods of presentation of subject matter
8. Teacher qualifications

Let us first glance at the summary of the answers which you gave at our last meeting pertaining to time allotment for physics in your various schools. It is both startling and illuminating.

1. The time in minutes per week varied from 210 in four schools to 330 in one, the average for all the schools being 251 minutes per week.

2. The average of the minimum time allotments which you specified as desirable to properly prepare our pupils to meet college entrance requirements was 338 minutes per week.

3. As to periods per week, 8% had 4, 48% had 5, 32% had 6, 12% had 7, and 1 school had 10 (5 double periods).

4. Seventy-nine per cent had 1 double period at least. Ninety-two per cent of the members voted in favor of double periods.

5. Very few of our members reported having made a request for more time, believing it to be hopeless. Of those who had requested more time four had been successful in gaining increases.

6. Many reported the necessity of holding extra afternoon classes for college preparatory groups.

I think we have already discovered a part of the answer to our question.

Before commenting on these figures, let us consider briefly what our objectives are, or should be. For college preparatory pupils, our objective, unfortunately, is limited to preparing them to successfully meet college entrance requirements. (This you have said could be done in about 338 minutes per week.)

For the pupil who is going to take further courses of physics in college this may perhaps pass as a worthy objective. But what of those who will not take college physics? What of those non-college preparatory or "academic" pupils, who, in our smaller high schools, must be placed in the same class with those (often very few), who are going to college? The above course, as we shall discuss later, fails lamentably to meet their needs. Our objective for these two groups should be preparation for every day living.

I firmly believe that the objective of the courses given to all three groups should be *preparation for life* and that the courses should be sufficiently comprehensive to merit and justify college entrance credits.

We must realize that for over 70% of our high school students who take physics this course is a *terminal* one.

Our high schools receive much justified criticism that we are not preparing our youth for life as we should. We are well aware of it. Assuming that preparation for life involves the acquiring of certain knowledge and skills for practical use, the establishing of worthwhile interests to carry through life for its enrichment and enjoyment, the development of the mind to think and reason clearly and with sufficient persistence to get somewhere, and perhaps, most important of all, the building of character and the raising of the plane of living to one of higher ethical, moral and spiritual level, how can we hope to successfully meet this privilege and duty through the medium of physics when held back as we are by present

restrictions? It can't be done. And yet the need of it is all the greater today, not only because of the chaotic social and economic conditions, but also because of the decadence of home life and of parental guidance, interest and control.

Physics has come to occupy a very different place in our every day life than it did comparatively a few years ago. It has grown enormously in content. An abridged rudimentary course of a few fundamental principles with very limited applications no longer meets our daily needs. Our pupils are surrounded by scores of recent developments, new appliances and devices which they want to know about and *should know about* and in which, incidentally, they are far more interested than in finding how many calories are needed to raise the temperature of 10 grams of iron 60 degrees, important as that topic is. If we would see an increase of enrollment in physics we must extend our courses to meet, within reason, the interests and future needs of our pupils. But, it cannot be done under our present time allotment.

We recently requested the pupils of our physics classes to write out and pass in, anonymously if they preferred, their criticisms of the physics course as it was being presented to them, urging them to give without fear their unfavorable criticisms as well as any favorable ones (if there were any). I am convinced from the results that it was a wise thing to do. We naturally expected to receive wide differences of reactions. A few of them wanted less problems, but, unexpectedly, a larger amount asked for more; some liked this and didn't like that, but the one criticism upon which most of them agreed, was *insufficient time*. They said, "We don't thoroughly master one topic before rushing on to the next. We need time for more class discussions, for more individual experiments and for opportunities to ask questions about practical applications."

These criticisms we expected and deserved, but we could do no better in the allotted time. We had tried to help out the situation by setting aside an afternoon for an extra class which was attended by perhaps a third of the group. A large majority wanted to come but were prevented by conflicts. But this is not sufficient. Our classes, at their own instigation, voted unanimously in favor of using a study period if it could be arranged, for an extra class. This had to be refused largely because of program conflicts. This experience revealed very clearly the need of more time as well as the pupils' eager desire for it.

Let us mention a few of the handicaps placed before us by present conditions of time allotments and college entrance examination restrictions.

Pressed for time, we are obliged to omit a great deal of subject matter which should be included for the enrichment of later life, for practical usefulness in every day experience, and for a real foundation upon which to build a possible later college course in physics. We know that college physics, as presented in many cases, is one of the most difficult courses to master, also that it often differs more from the high school courses than in almost any other subject. Conditions should enable us to make this ob-

jective of greater concern than the mere passing of entrance examinations. Instead of having frequent and unhurried class discussions, in which we can draw upon the wealth of information which our pupils have accumulated through previous years of observation and questioning, using it to lead *them* to explain phenomena, draw conclusions and state the laws, we find ourselves obliged to spend much of the time bombarding them with facts, figures, formulae and principles to be *learned*—a sort of high-pressure tutoring process. Our pupils are thus deprived to a considerable extent of the inspiring experiences of discovering things for themselves and of the mental growth which they would receive through stimulated thinking and reasoning.

Much of the material omitted would prove of greater interest than much that had been given as a minimum content. The almost complete omission of sound, for example, is not only unfortunate; it is *deplorable.* In view of its applications to radio and to music which play such an important part in our lives, its present insignificant place in physics should not be tolerated.

Under existing conditions it is small wonder that physics acquires the reputation of being a hard grind. Another result, which we are apt to overlook is that our graduates who later take a course of physics in college bring back the report that their high school course had been of very little help to them and recommend some other subject in its stead. It is imperative that we remove the causes of these dissatisfactions.

Physics is no longer a one-year course and has not been for many years. Why should the subject be limited to one year when English, modern languages, Latin, mathematics, and other subjects have from two to four years? Why should we not have a two-year course in physics and why should we not expect the colleges to give a two point credit towards admission?

Perhaps we may find it advisable to recommend that our pupils take either two years of physics or two years of chemistry. We physics teachers need have no fears that such a plan would result in a decreased enrollment in physics, for with the improved conditions our subject could be made much more inviting than it is at present. I believe it would result in a greatly increased enrollment, for, having taught both physics and chemistry, I feel that physics has far more fascinating mysteries related to every day experiences and also that it offers a greater scope of usefulness in common every-day experiences.

I believe the colleges would prefer students well grounded in either physics or chemistry than to receive pupils poorly prepared in one or the other, or both. We shall attempt to learn their reaction.

Having had five years of physics teaching in college, I know of many cases in which a high school course of the *anaemic* type which is given in so many schools, actually proved more of a hindrance than a help. Furthermore, I can understand and sympathize with college teachers who have said on occasions that they should prefer students who had had no previ-

ous high school course in the subject. They referred, of course, to the average pupil, not to the small minority of exceptionally bright and interested pupils who learned physics *in spite* of existing adverse conditions.

Should we eliminate more and more the mathematical problems in physics? My answer is, "No."

The fact that problem solving is distasteful to many of our students is not due half as much to lack of mathematical ability on their part as to our inability to devote the necessary time and effort to put it across. With, perhaps, an occasional bit of help in the mathematics we can very easily demonstrate to them that if they know their theory, a very little reasoning will bring success. With patience and skill we can soon have them enjoying problem solving and asking for more. They soon come to realize that their ability to handle the problems is an excellent way to measure their mastery of the subject.

Incidentally, we should give more thought than we sometimes do to a proper selection of problems. There should be many selected which have a practical bearing on every-day life. Also, many of us have found it advisable to have our pupils set up the problems, substituting the values but to omit the mathematics involved in solving for the answer. Furthermore, it helps a great deal to select numerical values which will simplify the tedious process of arithmetic by cancellations. The cutting down of long numbers to three or four figures by the use of the factor 10 with an exponent helps to make problem solving more pleasing.

We teachers of physics too often fail to realize the unusual opportunities which are placed in our hands to mold character and to do a great deal toward lifting the lives of our pupils to a higher spiritual plane.

Why should so many of us refrain from alluding now and then to the Infinite Creator and ruler of the universe, whose being fills all space, whose infinite wisdom and power are revealed through immeasurable energies, perfect orderliness and unchanging laws and whose interest in mankind is so clearly demonstrated by many phenomena which we study?

A consciousness of the omnipresence of God implanted in the hearts of men would certainly do much to curb the ungod-like tendencies rampant in the world. I am convinced that the unexpected mention of God in the classroom, revealing the teacher's consciousness of His presence and of His control of the universe, can be tremendously effective. I have never discovered an unfavorable reaction from a reference to God, but on the contrary, I have observed a very definite deepening of interest in the subject because of it.

A condition harmful to physics which exists in many schools is due to ineffective teaching. Most frequently this is caused by the assignment of one or more classes in physics to a teacher who, because of having had a one year's college physics course, is asked to give up classes in mathematics or some other subject, which he is better prepared to teach and in which he is deeply interested, to help solve some difficult problem in faculty adjustments. How could this teacher, thwarted in his plans, with no real

interest or background, be expected to do an inspiring or effective job at teaching physics?

Then again, it is generally believed, and with good reason, that teachers as a whole are inclined to be quite self-satisfied (not excepting physics teachers). They are quite apt to consider their teaching techniques to be most excellent and with an "I am Sir Oracle" attitude make quite sure that they impress their pupils with their profound knowledge and mastery of the subject. Not until they come to realize that humility is one of the outstanding qualities of the most successful teachers and, sensing their shortcomings, pursue a serious study of how to overcome them, will they be the most effective teachers.

Many teachers, for various and sundry reasons, are content to plod along, saying, "The methods of my forefathers are good enough for me." Steeped in sacred traditions, they continue along in deep trodden grooves, unmindful of the changing world about them.

They are quite successful in dulling, if not killing, whatever interest their pupils have brought with them on the first day of school. Quite likely they will hand their pupils a centimeter and inch rule, a rectangular and a cylindrical block of wood by which they are to find the ratio of the inch to the centimeter, the value of π, the volumes of the blocks and perhaps the density of the blocks. Then they send them home to study some very *important* tables of weights and measures in the metric and English systems with a goodly number of conversion problems to solve.

The victims sigh inwardly, try to look cheerful and interested and tackle the job, hoping for better things to come, but wondering down deep if this is a sample of what they have let themselves in for.

Let us consider in contrast the teacher who on the first day hurdles the desk and says, "Come on, let us go for a little trip" and leads them up into a high mountain where they may obtain a bird's-eye view of the realm of physics, fascinating, colorful, mysterious, intriguing, and wonderful, which they are going to explore, blazing trails of their own. He points out certain spots of great interest and importance and inspires them with the spirit of research and investigation. He then, perhaps, tells them soul-stirring bits about the valiant pioneers of science, of their great discoveries which have proved of such benefit to mankind. He assures them that there are thousands of adventurous men and women down there in that mysterious realm exploring day after day with thrilling delights from their ever increasing numbers of discoveries. He concludes by telling them of the vast, unexplored areas rich in treasures.

The next day when his pupils rush to class with faces alight with eager anticipation, he introduces them to that most marvelous and awe-inspiring of all concepts of physics, *Energy*. They learn of its infiniteness, that nothing can take place without it, that every particle in the universe, whether large or infinitesimally small possess some of this vast store of energy created by God in the beginning. Realizing the great help to be derived from their active imagination, their love of the abstract and the fascination

of their mental pictures, he deftly guides their untrained minds to sketch the beginnings of pictures which are to grow day by day, increasing in detail and perfection,—pictures which will prove to be as enduring as they are satisfying to behold.

This teacher mentions man's inability to create or destroy one single bit of energy but that he has learned, by conforming to the unchanging laws underlying the universe, how to change energy into a variety of forms; heat, light, electrical, mechanical and chemical, and how he may move huge quantities from one place to another to meet his needs.

Next comes an introduction to those mysterious and invisible molecules, atoms, and electrons. Certain facts about them are discovered and expectation is fostered by suggestions that with a knowledge of their motions, the forces between them and their peculiar characteristics we shall find explanations of scores of phenomena which are taking place every day about us.

Having pointed out these and a few other concepts he begins his exploration trips, acting as a *guide* rather than an *informant*. By this time his pupils are "raring" to go.

In making up his schedule he has considered the interest factor as of prime importance. He has found from experience that certain parts of mechanics, for example, are tough going, so, violating usual customs he postpones certain parts of it not needed in heat, light, or electricity to a later date when his pupils shall have become more seasoned explorers. If the need of a certain item arises, he reaches over into another chapter for it and inserts it. His pupils keenly interested in the immediate topic, realizing the need of this item, grasp it quickly.

In fact, this teacher is going to group topics throughout the course, not on the time-worn traditional basis, but on another basis, perhaps of energy conversions, or some other which he has found not only effective in maintaining interest but which brings a more complete and vivid understanding of the subject matter.

APPLICATIONS OF ELECTRICITY AND SOUND TO RADIO

Abstract of Demonstration by PROFESSOR J. R. HARRISON

Professor Harrison demonstrated a vertical type Tesla coil used for demonstrations. The secondary was at one end instead of at the center. It gave a 5–6″ spark and a good corona as the gap was increased. The current of .2 ampere is comparatively harmless due to the high frequency, most of the effect passing over the skin. In this way a 25-watt lamp could be lighted, and if a carbon bulb were used the current would be larger. With a 120 W, 220 V carbon lamp there would be probably 75 W on the body. Using a neon lamp it was not necessary to get very near the coil. A noticeable temperature rise occurred in the room due to the strong field.

As a generator the vacuum tube gives higher frequency currents. A radio high frequency furnace with a Hartley oscillator and two 100 W tubes in the circuit was demonstrated. It produced heat enough to raise iron in the coil almost to the melting point. An ordinary vacuum tube was outgassed in the field and heated in the coil to a glow. The furnace is relatively easy to make.

For piezo-electric purposes the best quality quartz comes from Brazil. There is a mine in California, but there is much twinning in the American crystals, and therefore more reject material, although these mines could be used in case of emergency. The piezo-electric property of quartz was discovered by Pierre Curie. He found that Rochelle salts or any asymetric crystals have this property. When squeezed or placed under strain an electric charge forms on the surface. The converse is also true. A dynamic effect was discovered later, the quartz acting like a tuning fork. This is used for standard pitch on the broadcasting station.

A sphere shows this in an electric radio frequency field using an oscillator but with two watts only. Two electrodes are connected. The lower is an old optical mirror in which the quartz sphere is placed, and the upper is a flat plate. A honey comb coil of 300 turns is used. The crystal is equivalent to a tuned series electrical circuit. The quartz crystal vibrates. The resultant, not the vibration can be seen. It will not oscillate if oil or dust are on the sphere. It can be cleaned with ether. Use of the sphere instead of rods or plates does away with the bother of orientation.

The sphere rolls and also rotates on nodes (electric axis). There are three electric axes perpendicular to the optical axis. If turned end for end it rotates in the opposite direction. There are dextro- and laevo-rotatory crystals.

Alexander Meissner discovered that ordinary crystals when in a high frequency field changed dimensions. This is vibrating mechanically, pumping air and vibrating it supersonically. There are two regions relative to the optical axis where much energy is given off. It is easy to set up an axis. If placed on a track it will rotate or walk, spin or slide. There are no particular applications as yet, but it makes a very pretty demonstration.

A Rochelle salt crystal with an argon lamp makes a piezo-electric apparatus which can be placed on a simple radio cone making a good microphone. With two stages of amplification it has a large enough output to operate an oscillograph.

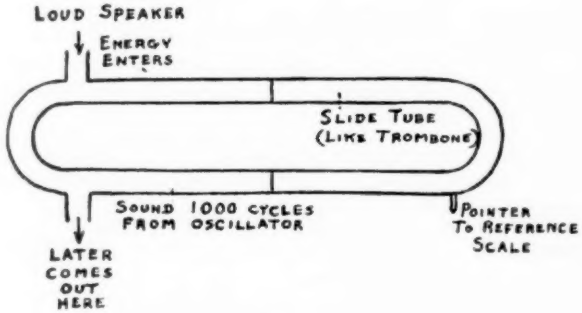


FIG. A

A radio application to an old sound experiment was the interference of sound in the old Quincke tube made by Rudolph Konig. Fig. A. A reference scale below the tube shows how far the sliding tube is moved. There are certain places where it is out of phase, and others where it is reinforced. This makes an excellent demonstration or laboratory experiment. By measuring between two distances where no sound is heard we get $\frac{1}{4}$ wave. length. By using a large tube the velocity is about the same as in free air. An amplifier and oscillator is used. The microphone should not be soldered

onto the tubes. A series of nodes is available and the results are more accurate than with the Kuntz tubes.

NEW LIGHT SOURCES FOR LECTURE AND LABORATORY

Abstract of Address by DR. RICHARD TOUSEY

Mercury arcs which have applications to teaching physics as well as other uses were discussed.

The old Cooper-Hewitt light was for medium pressure and current.

For producing light for fluorescence a low pressure and low current density lamp has been developed. It is a straight tube with a coiled oxide coated filament at either end. These are sources of electrons at first. They are then switched off and the charge goes through the vapor only. The fluorescent salt on the inside of the tube converts ultraviolet into visible light.

The conditions of the lamp to furnish the greatest possible amount of ultraviolet to excite the tube was then discussed,

About 2 watts of the total 15 go into visible radiations. The tubes have about 2 to 4 times the efficiency of tungsten lamps. At first an uncoated but special glass tube was used. Later ordinary glass coated with a fluorescent salt replaced this type.

A daylight effect is obtained by combining salts fluorescing different colors. These lights cast no shadow and are good to work under.

A 5-watt germicidal lamp has been developed. These are useful in killing bacteria, providing mercury radiation for laboratory experiments, for diffraction experiments with gratings, etc.

Lamps of the second class run at high pressure and current, and are efficient sources of ultraviolet.

DEMONSTRATIONS IN MECHANICS

Professor F. W. Pote demonstrated several thought-stimulating experiments in Mechanics. Among these were:

1. *Torques.* A large spool 7 or 8 inches in diameter and having a fairly long shaft (a large wire spool could be adapted for the purpose) was weighted in the shaft, and had a cord attached by the two ends to two points on the shaft, and was wound up to unroll from the lower part. Question: How will the spool roll when the cord is pulled? If a person says left, it rolls right, and vice versa or it may slide along depending on the angle at which the demonstrator pulls the cord. The spool painted with bright enamel makes an attractive thought stimulator.

2. *Neutral Equilibrium.* A 10 inch wooden cone placed on the side is visible throughout the room, and illustrates center of gravity undisturbed when the body is disturbed.

3. A similar idea was remarkably well shown by an apparatus consisting of a piece of plank 2 inches thick and about 2 feet long mounted on a base which could be leveled. The plank was cut at one end to form an inverted catenary. By two uprights a cord was held horizontally above the top edge of the plank forming the x axis. The caternary portion was covered with sandpaper to provide friction. A rectangular (oblong) figure and a triangular figure, both of wood, and both having the center of gravity 8 inches from the base were placed separately on the edge of the sloping surface, the Y-axis through the center of gravity. As the objects were rocked or moved on the surface the center of gravity marked by a thumb tack followed the horizontal cord, and illustrated the tilting rock idea. Fig. 1.

4. *Double Atwood's Machine.* The apparatus was arranged as shown in Fig. 2. The two small weights were not equal, but with the small pulley, equalled 1000 grams. As used, the equations given were:

$$a=\left(\frac{20}{820}\right) g$$

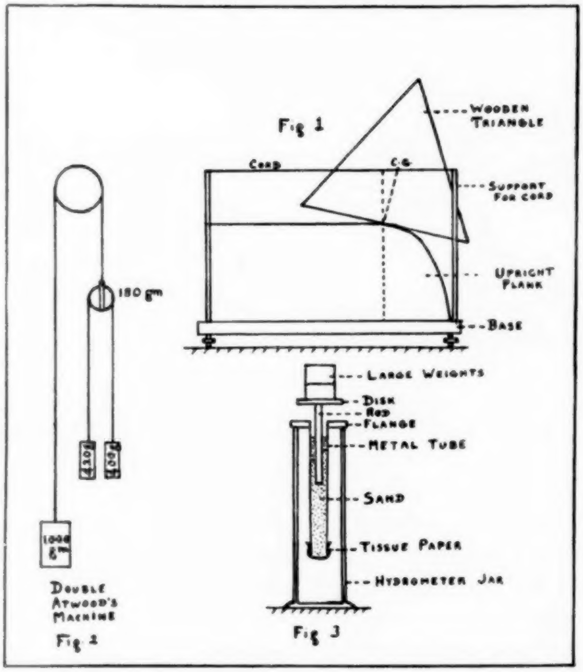
$$a=\frac{1}{41} g$$

$$T_2=\frac{40}{41}\times 42$$

$$T_1=\frac{42}{41}\times 40$$

$$410=T_1=T_2.$$

Then 2 forces under tension are equal.



5. *Inertia.* A cord, a heavy disc, a cylinder, and a chain were placed in turn on the rotator, and came into the horizontal position. A chain was linked together to form a circle about 10 inches in diameter, and placed over the pulley of a motor. The weight of the chain was adjusted to the speed of the motor. When revolving at high speed a small grooved pulley on a shaft held in the hand was touched to the revolving chain raising the chain from the motor pulley and pushing it off. The high speed of rotation caused the chain to act like a stiff hoop or wheel, and roll the length of the long lecture table and on to the floor beyond. There is a critical speed for each weight of chain.

6. *Resolution of Forces.* A tube with a flange so that it could be supported on a hydrometer jar had a piece of tissue paper tied over one end. A flat wooden disc on a rod several inches long was inserted in the tube after the latter was filled about ¾ full of sand. The rod was pressed down into the sand and weights were placed on the disc without breaking the paper. Fig. 3.

7. *Cohesion.* Two soft lead discs or hemispheres were used. They were fairly flat on the lower surface and had a ring through which a rod could be placed for a handle. The outside was trimmed with a knife and the flat surfaces were then pressed together. Fifteen to 18 kilograms were then suspended from the rod of the lower disc.

8. *Moment of Inertia.* Seated on a revolving "Cenco" stand and holding a fairly heavy metal sphere in each hand, the demonstrator controlled his speed of rotation by varying the distance the spheres were held out at either side.

9. *Mechanical Analogue of Resonance.* Pendulums attached to the same horizontal cord.

10. *Acceleration Produced by a Small Force.* A round bottom flask was inverted on the table and a board about three feet long having a weight placed on each end was balanced on the flask. The board was charged with static electricity, and a charged object held near it repelled it. gradually causing it to turn on the flask.

HIGH LIGHTS OF THE SUMMER SKIES

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[EDITOR'S NOTE:—This article concludes a series on popular astronomy. If these articles have been saved from month to month, they will make a convenient handbook of star charts and teaching activities for secondary schools.]

In the previous issues, we have confined ourselves to the aspect of the heavens for the current month only. This time, due to the suspension of the publication of SCHOOL SCIENCE AND MATHEMATICS for the summer months, we have attempted to cover the skies for June, July and August.

I. THE PLANETS

Mercury[1] will make one appearance in the evening sky in June, and one appearance in the morning sky in August. The dates and other data are as follows:

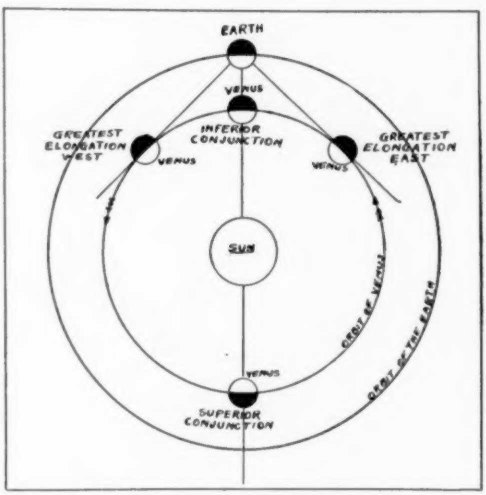
Greatest Elongation Eastward. (Evening Star)		Greatest Elongation Westward. (Morning Star)	
June 24	Magnitude +.7	August 10	Magnitude −.2

[1] *Mercury* can be seen low in the western sky shortly after sunset a few days before and after its greatest elongation east; and a similar situation exists in the eastern sky just before dawn a few days before and after *Mercury's* greatest elongation west.

Venus reaches inferior conjunction with the sun June 26, passing nearly between the earth and the sun at a distance of about 26,921,000 miles, appearing thereafter in the morning sky. Figure "A" will clearly indicate the positions of a planet at its greatest elongation eastward or westward, and a conjunction.

During the summer months *Venus* can be seen rising before the sun in the eastern sky. She reaches her greatest western elongation, or highest point in the eastern sky, on September 5. She reaches her greatest brilliance, however, on August 2, Magnitude −4.2.

The system of magnitudes has been handed down to us by Ptolemy, who about 150 A. D. classified the stars. He selected the twenty brightest stars as of the first magnitude. He then designated those just visible to the unaided eye as the sixth magnitude. Those between were given intermedi-



ate numbers. His system has been greatly extended by modern astronomers, and now includes stars of greater brilliance than the first magnitude. These are classified as 0 magnitude, and those of still greater brilliance as −1, −2 and so on. *Venus* is the brightest, with a magnitude at times of −4. Modern astronomers have even sub-divided the magnitudes into tenths of a magnitude. Each magnitude is 2.512 times, or roughly 2½ times brighter or dimmer than the next preceding, a standard first magnitude star being 100 times as bright as a sixth magnitude star. The 2.512 scale, now standard, was introduced by Pogson in 1850, 2.512 being the fifth root of 100, or the logarithm 0.4.

There is another system of magnitudes. This is called the absolute magnitude of a star. It is the magnitude or brightness of a star as it would appear if all the stars in the sky were placed at the same distance. Some


JULY 8½ 10 PM
JUNE 8½ 10 PM - AUGUST 8½ 10 PM

would appear dimmer, and some brighter than normal. Visual magnitude is no criterion of intrinsic luminosity.

Mars is an evening star until August 30, when it is in conjunction with the sun and appears thereafter in the morning sky. *Mars* is not a conspicuous object, and of very little interest at this time.

Jupiter and *Saturn* will be in the morning sky all summer. They appear close together and follow each other to the evening sky again November 3. *Uranus*, *Neptune* and *Pluto* are telescopic objects only, and are therefore of secondary interest.

II. Constellations and Stars

Perhaps one of the finest constellations along the Zodiac is *Scorpius*, the Scorpion. It is one of the few constellations which closely resembles its name. For those who can get a clear view of the southern sky, this constellation is an inspiring sight, with its long, sweeping stream of stars forming the tail of the Scorpion. The brightest star in *Scorpius* is *Antares*, meaning "Rival of Mars," both stars being red in color. *Antares* is about 163 light years away, and its diameter is about 186,000,000 miles, nearly as far as the distance from the earth to the sun.

As the season marches on, the summer half of the *Milky Way* comes into view. No discussion of the heavens would be complete without a reference to this aggregation of stars, the greatest of them all. To those situated away from the artificial light of a great city, the appearance of the *Milky Way* merits Milton's lines, when he said:

> "A broad and ample road whose dust is gold,
> And pavement stars."

To the unaided eye, it appears as a wide band of mist encircling the sky; but with even a small telescope, it is found to be composed of myriad tiny stars, and all sorts of other celestial objects. The *Milky Way* contains large clouds of opaque cosmic material, which have the appearance of dark splotches or streaks which blot out the light from the stars beyond. These dark clouds of cosmic dust can be seen with the unaided eye in many parts of the *Milky Way*. It will be noticed at the same time that the *Milky Way* also contains bright star clouds and clusters. The regions about *Sagittarius* and *Perseus* are perhaps the brightest. The stars there seem to pile up in great cumulus masses, like summer clouds.

The appearance of the *Milky Way* is to us one of perspective, and is due to the fact that we live on a tiny dark star in the midst of a vast and numberless aggregation of stars, nebula, star clusters, and other celestial matter, which is known as the *Galaxy*, or our *Galactic System*. Our *Galaxy* has roughly the shape of a disc, or two saucers placed rim to rim, with their bottoms outward thicker in the middle. From our position near the center, and looking outward, we observe what might be said to be the rim of this enormous wheel. We see the vast number of other stars in our system as a stream of celestial mist, due to their great distance. The *Milky Way*

stretches completely around us. Only half of it is visible at one time. In other parts of the sky we find many thousands of other stars, also members of this same vast system. Due to their relative proximity to us, they appear outside the *Milky Way*. Each individual star in our *Galaxy* is moving in its own independent way among the rest, while the entire *Galaxy* as a whole is known to be whirling like a pin wheel, spending millions of years in one revolution. There are other *Galactic Systems* out in space quite independent of our own. They are known as *Extra Galactic Systems*.

Three new constellations coming into view as summer passes are *Lyra*, the Lyre; *Cygnus*, the Swan; and *Aquila*, the Eagle. The brightest star in *Lyra* is the brilliant *Vega*, the second brightest star seen in this latitude. *Cygnus* contains *Deneb*, and in *Aquila* shines *Altair*.

The constellation *Lyra* is one of the smallest of the constellations. Two faint stars adjacent to and with *Vega* form a small equal-sided triangle. The northern star of the two is *Epsilon Lyra* and consists of a pair of stars very close together. With a telescope of sufficient power, each one of these is in turn seen as a double.

Turning to *Vega*, we learn that it has special significance for us here on this tiny earth. Our sun is moving through space with the velocity of about 12 miles per second, carrying the planets with it. The sun's motion is in the direction of *Vega*, and if *Vega* itself were not moving, we would reach the vicinity in about 380,000 years—a relatively short while as time goes, but when we reach the environs of the constellation *Lyra*, its stars will be millions of miles away in another direction. We will probably have the space all to ourselves.

Another conspicuous summer constellation worthy of mention is *Sagittarius*, the Archer. *Sagittarius* follows *Scorpius* along the Ecliptic, and has the appearance of two quadrilaterals joined by an imaginary line to a star to the north between them. Some of the greatest star clusters in the *Milky Way* are found in this region. Also in *Sagittarius* is the winter solstice, and on December 22 the Sun is in that constellation.

III. Classroom Activities

With Admiral Byrd at Little America, our attention this year is again directed southward. We wonder at the stories of the life found there, and of the eternal ice and snow. We discuss the possibilities of permanent settlements, of mineral resources and other things. We are apt to give so little attention to the heavens as seen from the southland, that it might be beneficial to teachers if we present a short discussion of astronomy as it is unfolded to Admiral Byrd and his followers from Little America to the south pole. The picture presented by the heavenly bodies is quite different there.

On June 21 at the south pole, the sun is $23\frac{1}{2}$ degrees below the horizon. It is completely dark for 24 hours each day. Winter is supreme. At the bottom of the earth, sunrise and sunset are rarities. Only once a year does the sun rise or set. On September 22, the sun appears in the north and

follows the horizon completely around in one day. As spring progresses, the sun rises higher each day, still circling the horizon as before. On December 22, the sun reaches its maximum height of $23\frac{1}{2}$ degrees, not one third as high as the summer sun in New York. The sun then gradually sinks each day until it sets once and for all on March 21.

There are not six months of darkness at Little America, however, which is quite a bit north of the pole. Twilight lasts for weeks, ending about the tenth of May. Admiral Byrd will only have to endure about two and one-half months of darkness. Even this darkness would be moderated by the moon, aurora and the stars. The moon would be visible only two weeks each month, from first quarter through full moon to the last quarter. The new moon would not be visible during that period. Dawn commences about the first of August, and lasts until the middle of September, when the sun first peeks above the horizon again. The further one gets from the absolute south pole, the more the sun would appear to deviate from its parallel path around the horizon, the path tilting higher in the north as we proceed away from the pole.

At the south pole, the stars never set. Neither do they rise. All the stars are circumpolar, and travel in great circles parallel to the horizon and each each other. They are visible at all times, when not lost in the rays of the sun.

For one standing at the south pole of the earth, there is only one direction. South, east and west disappear. All directions are north. But when one moves a bit from the pole, all the points of the compass appear again.

In the southern sky, there is no "south star," similar to *Polaris*, our "north star." Mariners navigating the southern seas steer by the *Southern Cross*, a bright constellation near the south celestial pole. This constellation appears on the flags of Australia and New Zealand. Other countries place its picture on their postage stamps.

Of course, the *Aurora Australis*, or southern lights, is visible at Little America. Scientists have discovered that many brilliant displays of southern and northern lights occur simultaneously. This leads some to believe that perhaps our south and north magnetic poles do in some unexplained manner contribute to the cause of these displays.

From the south pole and as far north as the tip of Florida, can be seen two luminous star clouds that resemble broken off portions of the *Milky Way*. They are known as the *Magellanic Clouds*. They were named after the Portuguese navigator. These are very important objects in the southern sky, and are subject to much speculation and study by astronomers.

Another phenomenon little discussed is the fact that by traveling from the equator to the south pole, we have actually gone down hill. Forgetting for the present the surface irregularities, we have actually traveled $13\frac{1}{2}$ miles closer to the center of the earth. The earth is flattened at the poles, and bulges at the equator. We would also weigh a little more at the south or north poles. If we tipped the scales at 150 pounds at the equator, we would weigh about twelve ounces more when we arrived at the pole, bar-

ring, of course, the extra weight of our fur jackets. There is, however, another factor that enters into our decreased weight at the equator. At the poles, we would not be whirling around with the earth. We are just turning once a day with the pivot at our feet. At the equator, we are spinning with the surface of the earth at the rate of about 1,000 miles an hour, and the centrifugal force tends to make us fly away, like a stone from a sling.

Conditions at the north pole are much the same. The only difference is the stars to be seen. None of the stars visible from the south pole can be seen from the north pole. *Polaris*, our north star, is directly overhead at all times. The other stars travel around *Polaris* in circular paths once a day, never setting nor rising. Always the same distance above the horizon.

Now that school is out and we have scattered to our favorite vacation spots, let us not forget that this is the season when we have our greatest opportunity to observe the heavens and apply what we have learned in the class-room. There are many interesting astronomical activities that can be planned both for camp and for the back yard. We submit a few suggestions.

(1) Summer "star parties" are becoming quite popular. Some local amateur will be glad to bring his telescope and give an explanation of celestial mechanics to a group of your friends some summer evening. Or the idea may be carried out on a grand scale, as described in POPULAR ASTRONOMY April, 1940, page 195.
(2) Construct a small telescope. AMATEUR TELESCOPE MAKING by Porter, gives full particulars, and can be had at most libraries.
(3) Photograph the stars, moon and meteor showers. Full details are available in SCHOOL SCIENCE AND MATHEMATICS, February, 1940.
(4) Gather postage stamps with astronomical features on the face. Many foreign countries have now and have had in the past astronomical figures on their stamps.
(5) Observe the motion of the earth and moon with a simple instrument, as described in SCHOOL SCIENCE AND MATHEMATICS, March, 1940. Page 275.

There are other suggestions that can be worked out by oneself, without outside help, such as making illuminated constellation charts, visiting the local observatory, or observatories along your route if you are on a vacation trip. A list of the larger ones is published in SCHOOL SCIENCE AND MATHEMATICS, May, 1940. Even making a sun dial for the camp or the lawn is instructive, as well as a lot of fun.

AMERICA'S SELF-SUFFICIENCY SHOWN IN NEW CHEMICAL DISPLAY AT WORLD'S FAIR

How the United States is attaining national self-sufficiency by its chemical research is shown in the exhibit of the E. I. du Pont de Nemours & Company which has been redesigned for the New York World's Fair.

Made-in-America materials are displayed which can replace former imports that in times of war may be difficult to obtain. Included in the display were: nitrates, dyes, medicinals, potash, synthetic rubber, optical glass, and camphor.

A feature of the exhibit this year will be the actual knitting of hosiery made of Nylon fiber; the synthetic materia! which is one of America's best answers to the Japanese domination of the natural silk trade.

PROBLEM DEPARTMENT

CONDUCTED BY G. H. JAMISON

State Teachers College, Kirksville, Mo.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink Problems and solutions will be credited to their authors. Each solution, or proposed problem, sent to the Editor should have the author's name introducing the problem or solution *as on the following pages.*

The editor of the department desires to serve its readers by making it interesting and helpfvlt to them. Address suggestions and problems to G. H. Jamison, State Teachers College, Kirksville, Missouri.

SOLUTIONS AND PROBLEMS

Note. Persons sending in solutions and submitting problems for solutions should observe the following instructions.

1. Drawings in India ink should be on a separate page from the solution.

2. Give the solution to the problem which you propose if you have one and also the source and any known references to it.

3. In general when several solutions are correct, the one submitted in the best form will be used.

LATE SOLUTIONS

1641, 43. *Samuel H. Barkan, Brooklyn, N. Y.*

1651. *Samuel H. Barkan, Julius Freilick, from Brooklyn, N. Y.*

1648. *Ezekiel W. Mundy, Syracuse, N. Y., Walter R. Warne, Rochester, N. Y., Levi P. Bird, Union Springs, N. Y.*

1646. *Walter R. Warne.*

1630. *Julius Freilich, Brooklyn, N. Y.*

1652. *Proposed by Nathan Altshiller-Court, University of Oklahoma.*

The line joining the midpoint M of the face $ABCD$ of a cube to the vertex E of the opposite face meets the sphere circumscribed about the cube in the point L. Show that $EM:EL::3:4$.

Solution by John Wagner, Chicago, Illinois

Pass a plane through A, C, and E, and there results an equilateral triangle ACE circumscribed by a circle. M is the midpoint of the side AC. Let the radius of the circle be r. EM (the altitude of the triangle ACE) $=3r/2$ and $EL=2r$.

$$\therefore \quad \frac{EM}{EL}=\frac{\frac{3r}{2}}{2r}=\frac{3}{4}.$$

Solutions were also offered by A. MacNeish, Chicago, Julius Freilich, Brooklyn, N. Y., David Blumstein, Brooklyn, N. Y., Samuel H. Barkan, Brooklyn, N. Y., George J. Ross, Brooklyn, N. Y., Paul C. Overstreet, Wilmore, Ky., Walter R. Warne, Rochester, N. Y., C. W. Trigg, Los

Angeles, Aaron Buchman, Buffalo, N. Y. Juanita Morrison Nash, Ada, Okla., Paul D. Thomas, Norman, Okla., Alan Wayne, N. Y., and also by the proposer.

1653. *Proposed by Dill Goodman, Fayette, N. Y.*

Prove that there are two and only two fractions with denominators less than 19 which have values between 10/13 and 4/5.

Solution by C. W. Trigg, Los Angeles City College

$$
\begin{array}{cccccccccccccccccc}
\frac{1}{2} & \frac{2}{3} & \frac{3}{4} & \frac{4}{5} & \frac{5}{6} & \frac{6}{7} & \frac{7}{8} & \frac{8}{9} & \frac{9}{10} & \frac{10}{11} & \frac{11}{12} & \frac{12}{13} & \frac{13}{14} & \frac{14}{15} & \frac{15}{16} & \frac{16}{17} & \frac{17}{18} & \cdots \\
\frac{1}{3} & \frac{2}{4} & \frac{3}{5} & \frac{4}{6} & \frac{5}{7} & \frac{6}{8} & \frac{7}{9} & \frac{8}{10} & \frac{9}{11} & \frac{10}{12} & \frac{11}{13} & \frac{12}{14} & \frac{13}{15} & \frac{14}{16} & \frac{15}{17} & \frac{16}{18} & \cdots & \\
\frac{1}{4} & \frac{2}{5} & \frac{3}{6} & \frac{4}{7} & \frac{5}{8} & \frac{6}{9} & \frac{7}{10} & \frac{8}{11} & \frac{9}{12} & \frac{10}{13} & \frac{11}{14} & \frac{12}{15} & \frac{13}{16} & \frac{14}{17} & \frac{15}{18} & \frac{16}{19} & \cdots & \\
\frac{1}{5} & \frac{2}{6} & \frac{3}{7} & \frac{4}{8} & \frac{5}{9} & \frac{6}{10} & \frac{7}{11} & \frac{8}{12} & \frac{9}{13} & \frac{10}{14} & \frac{11}{15} & \frac{12}{16} & \frac{13}{17} & \frac{14}{18} & \frac{15}{19} & \frac{16}{20} & \cdots & \\
\frac{1}{6} & \frac{2}{7} & \frac{3}{8} & \frac{4}{9} & \frac{5}{10} & \frac{6}{11} & \frac{7}{12} & \frac{8}{13} & \frac{9}{14} & \frac{10}{15} & \frac{11}{16} & \frac{12}{17} & \frac{13}{18} & \frac{14}{19} & \frac{15}{20} & \frac{16}{21} & \cdots & \\
\cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdots &
\end{array}
$$

Here the numerators of each row are consecutive integers beginning with unity. The denominators of each row are consecutive integers beginning with $k+1$ in the kth row. This array has the following properties:

(1) Each row is a series increasing toward the right;

(2) Each column is a series decreasing from the top;

(3) Each diagonal from upper right to lower left contains all the proper fractions with $(k+1)$ as a denominator.

(4) All elements of the principal diagonal from upper left to lower right are equal.

(5) The diagonals parallel to (4) and to the right form series decreasing from the top.

(6) The diagonals parallel to (4) and to the left form series increasing from the top.

(7) The ith element in the kth row equals the nith element in the nkth row.

By applying these properties the fractions greater than 3/4 may be blocked off and those less than 4/5 likewise may be segregated. There are but five which fall within the range which have denominators less than 19. Now $10/13 \div 13/17 = 170/169$ and $10/13 \div 7/9 = 90/91$, so there are but three fractions, 11/14, 7/9 and 14/18 (the last two being equal) with denominators less than 19 with values between 10/13 and 4/5. That these are actually within the desired range may be confirmed by the inequalities $450 < 455 < 468$ whence $10/13 < 7/9 < 4/5$, and $700 < 715 < 728$ whence $10/13 < 11/14 < 4/5$.

Second Solution by David X. Gordon, Brooklyn, N. Y.

Assume

$$10/13 < \frac{a-k}{a} < 4/5, \ a \text{ and } k \text{ integers, } a < 19.$$

The

$$10a < 13a - 13k \text{ and } 5a - 5k < 4a \text{ give}$$

$13k < 3a \qquad a < 5k$ or

$a/5 < k < 3a/13.$

For

$k=1$	a has no value
$k=2$	$a=9$
$k=3$	$a=14$
$k=4$	$a=18$

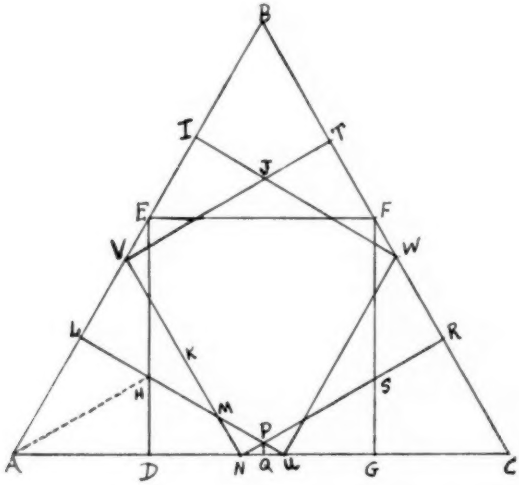
Hence the fractions are 7/9, 11/14 and 14/18 or 7/9 which satisfy the conditions.

A solution was also offered by **John F. Wagner, Chicago, Ill.**

1654. *Proposed by Charles W. Trigg, Cumnock College, Los Angeles.*

In an equilateral triangle three squares are inscribed. Find the ratios of the areas which are included in three, two, one and no squares to the area of the triangle.

Solution by the Proposer.



In the equilateral triangle ABC, let $EFGD$ be a typical inscribed square of side b. Then triangle BEF is also equilateral so $BE=BF=EF=FG=GD=DE=AN=b$. Set $AB=BC=CA=b+c$, then $AE=CF=CN=c$.

Indicate the outer area at the three vertices which is included in no square by 0; the area along LI, DK and TR which is included by one square by I; the triangular areas in two squares at V, E, J, F, W, U and N by II, and the common area which occurs in three squares by III. From considerations of parallelism and symmetry it may be seen that the triangle is broken up into a number of 30°–60° right triangles, and groups of equivalent areas, so we may conclude that

$$0=6\,\triangle AHD,$$

$$\mathrm{I}=6\,DHMN+6\,\triangle NPQ,$$

$$\mathrm{II}=6\,\triangle HKM+6\,\triangle MNP, \text{ and}$$

$$\mathrm{III}=\triangle ABC-(0+\mathrm{I}+\mathrm{II}).$$

From the various 30°–60° right triangles,

$$AE = \frac{2}{\sqrt{3}} ED = \frac{2}{\sqrt{3}} b = c.$$

$$AD = \tfrac{1}{2} AE = \frac{1}{\sqrt{3}} b.$$

$$HD = \frac{1}{\sqrt{3}} AD = \tfrac{1}{3} b.$$

$$AH = 2HD = \tfrac{2}{3} b.$$

$$AK = \sqrt{3}\, KN = \frac{\sqrt{3}}{2} b.$$

$$HK = AK - AH = b\left(\frac{\sqrt{3}}{2} - \frac{2}{3}\right) = b\left(\frac{3\sqrt{3}-4}{6}\right).$$

$$KM = \sqrt{3}\, HK = b\left(\frac{9-4\sqrt{3}}{6}\right).$$

$$MN = KN - KM = b\left(\frac{4\sqrt{3}-6}{6}\right).$$

$$PN = \frac{1}{\sqrt{3}} MN = b\left(\frac{4\sqrt{3}-6}{6\sqrt{3}}\right) = b\left(\frac{2-\sqrt{3}}{3}\right).$$

$$PQ = \tfrac{1}{2} PN = b\left(\frac{2-\sqrt{3}}{6}\right).$$

$$NQ = \sqrt{3}\, PQ = b\left(\frac{2\sqrt{3}-3}{6}\right).$$

$$AB = AE + BE = b\left(\frac{2\sqrt{3}+3}{3}\right).$$

Then

$$\triangle AHD = \tfrac{1}{2} AD \cdot HD = \frac{\sqrt{3}}{18} b^2.$$

$$\triangle HKM = \tfrac{1}{2} HK \cdot KM = b^2\left(\frac{43\sqrt{3}-72}{72}\right).$$

$$DHMN = \triangle AKN - \triangle AHD - \triangle HKM$$

$$= b^2\left(\frac{\sqrt{3}}{8} - \frac{\sqrt{3}}{18} - \frac{43\sqrt{3}-72}{72}\right) = b^2\left(\frac{72-38\sqrt{3}}{72}\right).$$

$$\triangle MPN = \tfrac{1}{2} MN \cdot PN = b^2\left(\frac{14\sqrt{3}-24}{36}\right).$$

$$\triangle PQN = \tfrac{1}{2} PQ \cdot QN = b^2\left(\frac{7\sqrt{3}-12}{72}\right).$$

So,

$$0 = \frac{\sqrt{3}}{3} b^2.$$

$$\mathrm{I} = \left(\frac{36-19\sqrt{3}}{6} + \frac{7\sqrt{3}-12}{12}\right) b^2 = \frac{60-31\sqrt{3}}{12} b^2.$$

$$\text{II}=\left(\frac{43\sqrt{3}-72}{12}+\frac{14\sqrt{3}-24}{6}\right)b^2=\frac{71\sqrt{3}-120}{1}\,b^2.$$

$$\text{III}=\frac{1}{2}\left(\frac{2\sqrt{3}+3}{3}\right)^2\frac{\sqrt{3}}{2}\,b^2-0-\text{I}-\text{II}=\frac{72-37\sqrt{3}}{12}\,b^2.$$

Therefore,

$$0:\text{I}:\text{II}:\text{III}:ABC::4\sqrt{3}:(60-31\sqrt{3}):(71\sqrt{3}-120):(72-37\sqrt{3}):(12+7\sqrt{3})$$
$$::0.2864:0.2744:0.0956:0.3436:1.$$

A solution was also offered by W. R. Smith, Chicago, Ill.

1655. *Proposed by Mr. Haivsen, St. Paul, Minn.*

If a, b, c, are different and if

$$\begin{vmatrix} a & a^3 & a^4-1 \\ b & b^3 & b^4-1 \\ c & c^3 & c^4-1 \end{vmatrix}=0$$

show that $abc(ab+bc+ca)=a+b+c$

Solution by Arthur Danzel, Collegeville, Minn.

$$\begin{vmatrix} a & a^3 & a^4-1 \\ b & b^3 & b^4-1 \\ c & c^3 & c^4-1 \end{vmatrix}=0 \quad\text{or}\quad \begin{vmatrix} a & a^3 & a^4 \\ b & b^3 & b^4 \\ c & c^3 & c^4 \end{vmatrix}=\begin{vmatrix} a & a^3 & 1 \\ b & b^3 & 1 \\ c & c^3 & 1 \end{vmatrix} \quad\text{or}$$

$$abc\begin{vmatrix} 1 & a^2 & a^3 \\ 1 & b^2 & b^3 \\ 1 & c^2 & c^3 \end{vmatrix}=\begin{vmatrix} a & a^3 & 1 \\ b & b^3 & 1 \\ c & c^3 & 1 \end{vmatrix} \quad\text{or}$$

$$abc\begin{vmatrix} 0 & a^2-b^2 & a^3-b^3 \\ 0 & b^2-c^2 & b^3-c^3 \\ 1 & c^2 & c^3 \end{vmatrix}=\begin{vmatrix} a-b & a^3-b^3 & 0 \\ b-c & b^3-c^3 & 0 \\ c & c^3 & 1 \end{vmatrix}$$

Factoring $(a-b)$ and $(b-c)$ from the 1st and 2nd row respectively from each determinant and reducing, we get:

$$abc\begin{vmatrix} a+b & a^2+ab+b^2 \\ b+c & b^2+bc+c^2 \end{vmatrix}=\begin{vmatrix} 1 & a^2+ab+b^2 \\ 1 & b^2+bc+c^2 \end{vmatrix}.$$

Expanding, collecting terms and factoring we obtain:

$$abc[b(c+a)+ac](c-a)=(b+c+a)(c-a) \quad\text{or}\quad abc(ab+bc+ca)=a+b+c.$$

Solutions were also offered by C. W. Trigg, Los Angeles, Frederic E. Nemmers, University of Iowa, George J. Ross, Brooklyn, N. Y., B. Felix John, Pittsburgh, Pa., David X. Gordon, Brooklyn, N. Y., Walter R. Warne, Rochester, N. Y., Aaron Buchman, Buffalo, N. Y. John F. Wagner, Chicago, Alan Wayne, New York.

1656. *Proposed by Arthur Brooks, Ledger, N. Y.*

Prove that $10^n-(5+\sqrt{17})^n-(5-\sqrt{17})^n$ is divisible by 2^{n+1}

Solution by David Gordon, Brooklyn, New York

(A) $\quad 10^n-(5+\sqrt{17})^n-(5-\sqrt{17})^n$ is divisible by 2^{n+1} if

(B) $\quad 5^n-\left(\frac{5+\sqrt{17}}{2}\right)^n-\left(\frac{5+\sqrt{17}}{2}\right)^n$ is divisible by 2.

(C) $$\left(\frac{5+\sqrt{17}}{2}\right)^n+\left(\frac{5-\sqrt{17}}{2}\right)^n \text{ must be odd.}$$

Let

$$\frac{5+\sqrt{17}}{2}=a \quad \text{and} \quad \frac{5-\sqrt{17}}{2}=b$$

Then

$$a+b=5 \qquad ab=2.$$

Substituting in the identity

$$a^n+b^n\equiv(a+b)(a^{n-1}+b^{n-1})-ab(a^{n-2}+b^{n-2}), \text{ we get}$$

(D) $$a^n+b^n\equiv 5(a^{n-1}+b^{n-1})-2(a^{n-2}+b^{n-2})$$

which says that a^n+b^n is odd if $a^{n-1}+b^{n-1}$ is odd. Since $a+b$ is odd, a^2+b^2 is odd, and so up to a^n+b^n.

Also a^n+b^n is integral, since $a+b=5$, $a^2+b^2=21$ and higher powers are obtained by subtracting integral multiples of these, as indicated in (D).

(B) will be even, since the difference of two odd integers is divisible by 2. This establishes the truth of (A).

1657. *Proposed by Cecil B. Read, Wichita, Kansas*

Show that $n^n>1\cdot 3\cdot 5\cdot 7\cdots(2n-1)$.

Solution by Frederic E. Nemmers, University of Iowa

$$\frac{1+3+5+7+\cdots+(2n-1)}{n}>[(1\cdot 3\cdot 5\cdot 7\cdots(2n-1)]^{1/n}$$

from the theorem that the arithmetic mean of a set of numbers, not all equal, is greater than their geometric mean.

Since

$$1+3+5+\cdots+(2n-1)=n^2.$$

Therefore

$$n^2/n>[1\cdot 3\cdot 5\cdot 7\cdots(2n-1)]^{1/n}$$
$$n>[1\cdot 3\cdot 5\cdot 7\cdots(2n-1)]^{1/n}$$
$$n^n>1\cdot 3\cdot 5\cdot 7\cdots(2n-1).$$

Solutions were also offered by C. W. Trigg, Los Angeles, David Blumstein, Brooklyn, N. Y., John F. Wagner, Chicago, Ill., George J. Ross, Brooklyn, New York, Paul C. Overstreet, Wilmore, Kentucky, Aaron Buchman, Buffalo, New York, Walter R. Warner, Rochester, New York, and also by the proposer.

HIGH SCHOOL HONOR ROLL

The Editor will be very happy to make special mention of high school classes, clubs, or individual students who offer solutions to problems submitted in this department. Teachers are urged to report to the Editor such solutions.

For this issue the Honor Roll appears below:

1652. *T. E. Hull, Sidney V. Soanes, from Upper Canada College, Lawrence Vallentyne, Red Bluff Union H.S., Calif.*

1655. *Douglas G. Buckley, T. E. Hull, R. W. L. Lardlaw, and Sidney V. Soanes from Upper Canada College.*

LATE SOLUTION

1595. *Proposed by Richard Doner, Syracuse, N. Y.*

Through a given point draw two transversals which shall intercept given lengths on two given lines.

Solution by E. H. Umberger, Chicago, Ill.

Let the given lines be L, M, the given lengths c, d, and the given point P. If L, M are parallel, the construction is possible if and only if c, d are proportional to the distances from P to L, M, in which case there are infinitely many solutions.

Let L, M intersect in O and be the axes of an oblique (ξ, η) coördinate system, directed so that $P(a, b)$ is in the first quadrant.

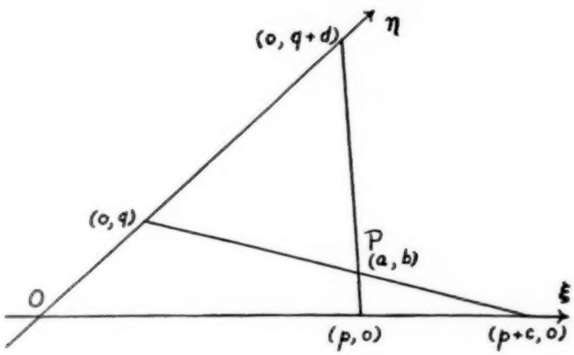


Fig. 1

We desire p, q such that the point-triples $(p, 0)$, (a, b), $(0, q+d)$ and $(p+c, 0)$, (a, b), $(0, q)$ are collinear (Fig. 1).
Hence

$$\begin{vmatrix} p & 0 & 1 \\ a & b & 1 \\ 0 & q+d & 1 \end{vmatrix} = 0; \tag{1}$$

$$\begin{vmatrix} p+c & 0 & 1 \\ a & b & 1 \\ 0 & q & 1 \end{vmatrix} = 0. \tag{2}$$

Eliminating p between (1) and (2),

$$q = b - \frac{d}{2} \pm l, \tag{3}$$

where

$$l^2 = d\left(\frac{ab}{c} + \frac{d}{4}\right). \tag{4}$$

Various constructions are possible; one is given in Fig. 2, where we suppose the same coordinate system as in Fig. 1. The points are obtained in alphabetical order, and the steps by which they are determined are clear from the coördinates.

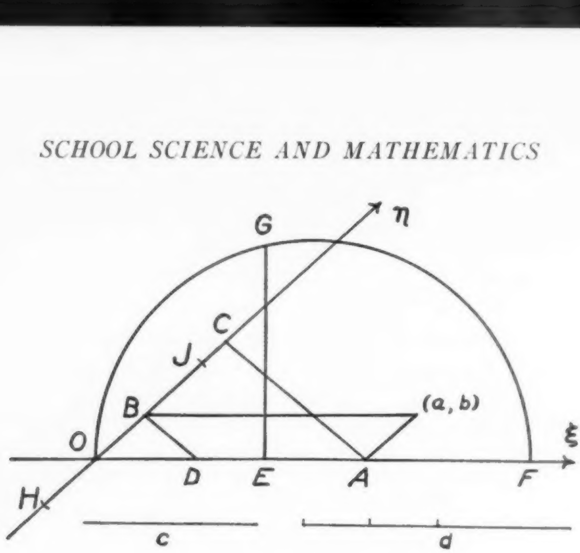


FIG. 2

$$A=(a, 0); \qquad B=(0, b); \qquad C=(0, c).$$

Through B construct a parallel to AC, obtaining

$$D=\left(\frac{ab}{c},\ 0\right).$$

$$E=\left(\frac{ab}{c}+\frac{d}{4},\ 0\right); \qquad F=\left(\frac{ab}{c}+\frac{5d}{4},\ 0\right).$$

Erect a perpendicular to OF at E and construct on diameter OF a semicircle which intersects the perpendicular in G. Whence from (4) we have

$$\overline{EG}=l, \qquad H=\left(0, b-\frac{d}{2}\right) \text{ and from (3)}$$

$$J=\left(0, b-\frac{d}{2}+l\right)=(0, q),$$

The points $(0, q+d)$, $(p, 0)$, $(p+c, 0)$ are now obtained by the properties evidence in Fig. 1.

Note. The point, $(0,\ b-d/2-l)$, not shown in Fig. 2, yields a second solution. We have supposed that c, d have the same sign and are intercepted on $O\xi$, $O\eta$ respectively. By reversing the correspondence, we obtain another set of solutions. If c, d have opposite signs, we can construct $(0, q)$ if and only if the right member of (4) is nonnegative, i.e.,

$$4ab \leqq -cd.$$

In general, if we do not assign a meaning as to distance, we can effect the desired construction in eight ways if $4ab<cd$, in six ways if $4ab=cd$, and in four ways if $4ab>cd$.

PROBLEMS FOR SOLUTION

1670. *Proposed by Garrett Freeleigh, Watertown, New York.*

Show that the area of a triangle, whose sides are a, b, c, is

$$\tfrac{1}{4}\sqrt{2a^2b^2+2a^2c^2+2b^2c^2-a^4-b^4-c^4}.$$

1671. *Proposed by Hugo Brandt.*

For the curve $y=x^x$, find

a. The value for $x=0$

b. The minimum value for y
c. The inclination of tangent for $x=1$

1672. *Proposed by Cecil B. Read, Wichita, Kansas.*
If $\tan x = \tan 3y$ and $\tan 2y = 2\tan z$, prove that $x+y-z=n\pi$.

1673. *Proposed by William W. Johnson, Cleveland, Ohio.*
Solve for x:

$$\left(\frac{x-a+b}{x+a-b}\right)^2=\left(1+\frac{2x}{a}\right)^2+\left(1+\frac{2x}{b}\right)^2-9.$$

1674. *Proposed by Charles W. Trigg, Los Angeles.*
The area of a triangle is equal to the sum of the squares of its sides divided by four times the sum of the cotangents of its angles.

1675. *Proposed by S. V. Soanes, Upper Canada College, Toronto.*
Solve the system

$$\begin{aligned} x+y+z+w&=10\\ x^2+y^2+z^2+w^2&=30\\ x^3+y^3+z^3+w^3&=100\\ xyzw&=24. \end{aligned}$$

SCIENCE QUESTIONS

June, 1940

Conducted by Franklin T. Jones
10109 Wilbur Avenue, SE, Cleveland, Ohio

DO YOU KNOW THE ANSWERS?

96. When is a bloodstain green?*
* (From a folder advertising THE PEOPLE'S LIBRARY, The Macmillan Company, N.Y.)
97. *How many red blood corpuscles are formed in the marrow of your bones per second?
98. *How does a lie detector catch you in a lie?
99. *What will light pass through that sound will not?
100. What is the area of the South Magnetic Pole?
(*Science News Letter*, for April 27, 1940)

Answers to April Questions

86. Q—Explain why oxidation is generally reduction.
Answer—When wood or coal are oxidized, they are *reduced* to ashes.
87. Q—Name this peculiar chemical compound (HIO)Ag.
Answer—Heigh Ho, Silver!!!
88. Skis were invented in Lapland.
89. Cuba is a supply for manganese in the Western Hemisphere.
90. "Man is the longest lived mammal" says Major Stanley S. Flower, British zoologist.

WANTED

QUESTIONS—TESTS—EXAMINATION PAPERS—ANSWERS

Questions your pupils should answer correctly but do not.
Questions that aroused discussion in your classes.
The fun as well as the serious in science teaching.

Join the Guild of Question Raisers and Answerers (GQRA)
Pupils and classes are eligible as well as teachers and outsiders.
343 are already members!

GQRA—NEW MEMBERS, June, 1940

338. *W. G. Lawrence, Instructor in Chemistry, West High School, Cleveland.*
339. *Dr. J. J. Nassau, Professor of Astronomy, Case School of Applied Science, Cleveland, Ohio.*
340. *Ruth Farrell, Mercy High School, Milwaukee, Wis.*
341. *Lois Thielen, Mercy High School, Milwaukee, Wis.*
342. *Marian Berres, Mercy High School, Milwaukee, Wis.*
343. *Henry G. Weaver, Director, Customer Research Staff, General Motors Corporation, Detroit, Mich.*

"PREVIEWS OF PROGRESS IN THE COMING CENTURY"

"A Booklet containing excerpts from addresses by leading Scientists, Educators, and Industrialists." Kettering, Frank, Compton, Corbett, Gray, Wilson, Aylesworth, Fishbein, Pitkin.

To be obtained by writing to HENRY G. WEAVER, Director, Customer Research Staff, 3044 West Grand Boulevard, Detroit, Mich. (Elected to the GQRA, No. 343). Please refer to this notice.

WHAT SIMPLE MACHINE?

893. *Proposed by Philip B. Sharpe (GQRA, No.* **262**)*, Greenwich, N. Y.*
What Simple Machine is the Battering Ram?

(Note that a simple machine changes the rate of doing work.)

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888. *What Simple Machines are these?* (Selected from the question as published in SCHOOL SCIENCE AND MATHEMATICS, April, 1940.)

(a) A transom-opener?
(b) Airplane wings?
(c) Gears?
(d) Differential pulleys?
(e) A hydraulic press?
(f) Wagon wheels?

SCRAMBLED WORDS

894. *Proposed by Marian Berres, Mercy High School, Milwaukee, Wis. (Elected to the GQRA, No. 342).*

"I made up a list of 'Scrambled Words' for the monthly meeting of the Bio-ite Club. Very few girls could unscramble them. I wonder if the readers of SCHOOL SCIENCE AND MATHEMATICS *could do it.*

They are from our regular class subjects and are as follows:

(1) *Ylacriortuc*—a system of our body.
(2) *Lapfinaol*—name of tubes in our reproductory system.
(3) *Rtaegacli*—the elastic stage that bones are in in early life.
(4) *Meligant*—connective tissues that bind bone to bone.
(5) *Altepla*—bone of our body.
(6) *Raymlalch*—gland of our body.
(7) *Upaclas*—bone of our body.
(8) *Spnrioet*—a class of nutrients composed of nitrogen, carbon, hydrogen and oxygen.

(9) *Snokiped*—bone of our body.
(10) *Mymmarm*—glands in our body.

NEW TEST IN CHEMISTRY—(Please Note Form)

895. *Given by Brother M. Edward* (*GQRA, No.* 136) *at Catholic High School, Pittsburgh, Pa.*

It is very interesting to compare the form of this test with the "fill in the blanks" forms, and "select the statement that is true" forms, and the "Yes" and "No" forms which have become so frequently used by teachers since about 1918. *Here is a divergence from those forms which still will make it easier for the teacher to mark the papers and not remove quite all the demand for thinking on the part of the student. Try re-casting some of your questions into this form and see if you do not like it.—ED.*

(The first half of the test is given in this issue, questions 1 to 50. The remaining questions will be published in the October number.)

CHEMISTRY

DIRECTIONS: Prepare an *answer sheet* as follows:

Draw a line down the center of the sheet of loose-leaf paper both front and back. Starting from the *very first line* and going down place in the left-hand column numbers from 1 to 25, in the right hand column from 26 to 50. On the reverse side 51 to 75 on the left and 76 to 100 on the right. Place your *name and number* close to the top edge (*not* on the first line). All questions must be answered on the lines of the answer sheet corresponding in number with the question. (No credit if done otherwise than directed.)

1. What natural substance is the source of most of our liquid fuels?
2. What natural substance is the source of our best solid fuels?
3. What name is given to the process of heating a substance in the absence of air, in order to drive off the volatile matter present?
4. What name is given to the process of separating a mixture of liquids according to the difference in boiling points each possess?
5. How is the percentage of gasoline obtained from crude oil increased beyond the normal amount that is present—just name process?
6. What substance is made in the By-product Ovens (solid only)?
7. What fuel gas is made by the reaction of water on calcium carbide?
8. What substance (solid) is obtained by the heating of wood in the absence of air?
9. What substance is added to gasoline to give it anti-knock properties?
10. What system of rating (name only) is used to compare anti-knock qualities of gasoline?
11. What substance is known as "marsh gas" or "fire damp" (in mines)?
12. What substance is formed by the incomplete combustion of carbon or carbon fuels?
13. Give the *general formula* for the members of the *paraffin* series?
14. What is the technical name for hard coal?
15. What is the technical name for soft coal?
16. What crystalline allotropic form of carbon is soft and slippery?
17. What crystalline form of carbon is hard and usually colorless?
18. Which of the following men is responsible for the invention of the mine Safety Lamp? *Arrhenius, Frasch, Davy, Acheson* or *Cox?*
19. What fuel gas is made by passing steam over red hot coke or coal?
20. What amorphous form of carbon is made by burning oils in a limited supply of air, while a cool object is moved through the flame to collect the deposit of carbon cooled below its kindling temperature?

21. What amorphous form of carbon is used to decolorize the sirups in the refining of sugar?
22. What gas destroys the red corpuscles of the blood—producing death by forming a stable compound with blood and thereby keeping O_2 away?
23. What branch of chemistry deals solely with the carbon compounds?
24. What olefin gas is used to ripen fruit and also as an anesthetic?
25. Kerosene boils at a lower temperature than gasoline (true or false)

(Check off answered questions)

Answer these questions in the right-hand column of front side of answer sheet

26. Who proposed the present method of extracting sulfur from the earth?
27. What purpose is the 1-inch pipe in the method referred to above?
28. If water boils at 100 degrees C., how is it possible to get liquid water to a temperature of 167 degrees C. in order to melt the sulfur?
29. What form of sulfur is produced when boiling sulfur is poured into cold water?
30. What name is given to the very fine powder of sulfur that is made commercially by distilling sulfur and condensing in brick chambers?

31.
32. What two states produce sulfur on a large scale (list alphabetically)?

33. Write the chemical equation that shows the combustion of sulfur?

Which of the following equations are correct (*CORRECT* * *INCORRECT*) (use one of these words)

34. $Cu + H_2SO_4 \rightarrow CuSO_4 + H_2$
35. $4Cu + H_2SO_4 \rightarrow 4CuO + H_2S$
36. $Cu + 2H_2SO_4 \rightarrow CuSO_4 + 2H_2O + SO_2$
37. $Cu + H_2SO_4 \rightarrow CuSO_3 + H_2O$ DON'T
38. $Zn + H_2SO_4 \rightarrow ZnSO_4 + H_2$ PLACE
39. $FeS + H_2SO_4 \rightarrow FeSO_4 + H_2S$ ANSWERS
40. $SO_2 + H_2O \rightarrow H_2SO_3$ HERE
41. $SO_2 + 2H_2O \rightarrow H_2SO_4 + H_2$
42. $2SO_2 + O_2 \rightarrow 2SO_3$
43. $CaCO_3 \rightarrow CaO + CO_2$
44. Why is sulfuric acid used in the manufacture of other acids?
45. What property of conc. sulfuric acid caused it to react with sugar?
46. Name the process used in making the purest grade of sulfuric acid?
47. Name one other process for making the acid commercially.
48. Under what conditions only does H_2SO_4 act as an acid?
49. For what purpose do steel mills use large quantities of H_2SO_4?
50. If you were diluting sulfuric acid would you pour the *acid into the water* or the *water into the acid?* (write full phrase)

(*Questions* 51 *to* 100 *to be published later.*)

THE SCHMIDT TELESCOPIC SYSTEM

882. *Suggested by the proposed new Schmidt Telescope at The Warner & Swasey Observatory of Case School of Applied Science.*

Memorandum and Illustration dictated by Dr. J. J. Nassau, Professor of Astronomy, Case School of Applied Science (Elected to the GQRA, No. 339).

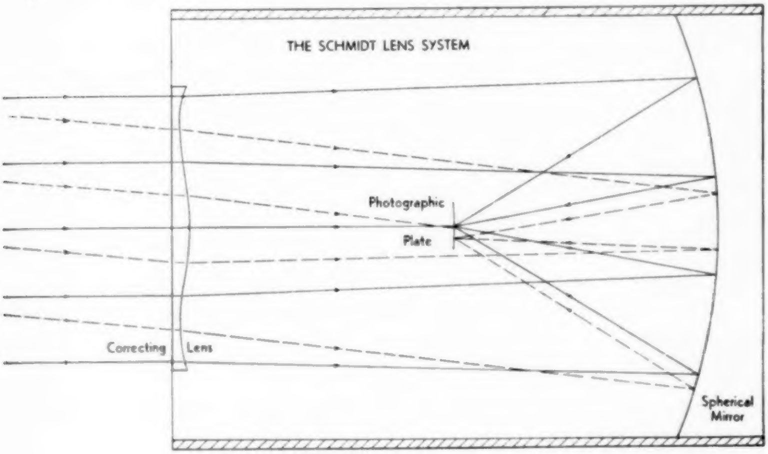
The principle of the Schmidt Telescope is a relatively simple one. The

optical parts are a spherical mirror and a thin lens. One surface of the lens is a plane and the other is in the form of a fourth degree curve.

The correcting lens is placed in front of the mirror at a distance equal to the radius of the spherical mirror. The photographic plate is placed nearly halfway between the lens and the mirror. The plate is bent towards the mirror to a sphere. The radius of that sphere is equal to half that of the mirror.

The principal advantages of the Schmidt telescope are—

a) A wide field many times that of the ordinary reflector;
b) Ability to build the telescope with a very short focus where great speeds are desired, as for example, F/1, telescopes have been built;



c) Since the lens is very thin, there is no appreciable chromatic aberration;
d) It has a remarkable resolving power.

At present there are four large Schmidt telescopes in progress—

1) A Schmidt-type telescope at Mt. Palomar, 72" mirror and 48" lens, a photographic plate 17" in diameter;
2) One at Bloemfontein South Africa, for Harvard, 60" diameter mirror and 60" lens;
3) One for the Warner & Swasey Observatory of Case School of Applied Science, 36" mirror, 24" lens, 8" diameter photographic plate;
4) One for Harvard Observatory at Oak Ridge, Mass., 33" mirror, 24" lens, 8" diameter of photographic plate.

Reference for a non-technical reader, POPULAR ASTRONOMY, Vol. 44 page 15, *1936. "The Schmidt Camera" by C. H. Smiley.*

b) *What is the purpose of the lenses and mirrors in the modern telescope?*

Answer—To gather light and bring it to a focus.

c) *What is the fundamental difference between the refracting and reflecting systems in telescopes?*

Answer—Light is gathered by a lens in the refractor and by a mirror in the reflector.

d) *What great discoverers devised the first instrument of each kind?*

Answer—Credit for the refractor goes to Galileo, for the reflector to Sir Isaac Newton.

EXPERIENCE WITH STUMP-BURNING

887. *The farmers in the country say—*

"You can bore a hole in the cut surface of a fresh stump, put in some saltpeter, let the stump stand until it dries out in the spring or early summer, light it and it will burn completely clear down into the roots."

Answer by E. M. Tingley (GQRA, No. 296)

This idea is more than 55 years old.

"In 1937 a green maple tree two feet in diameter was cut about 8 inches above the surface of our lawn.

"In the summer of 1938 ten $\frac{3}{4}$ inch holes 4 inches deep were bored into the top of the stump and into the root branches. Holes were filled with saltpeter and water and refilled occasionally.

"Last August when the stump was dry it was burned to a few inches below the ground level with the help of several scuttles of lump petroleum carbon. The stump would not have burned much without assistance.

"To those who may try this stump-burning stunt the following suggestions are made.

(1) Employ a husky operator with a two-hand ship augur to bore in the stump many $1\frac{1}{2}$ inch holes 6 inches deep. Do not terminate holes in rotten wood as the saltepeter will leak away.

(2) Bore the holes at a small angle with the wood grain to favor absorption.

(3) Keep holes full of solution during winter until dry weather begins.

(4) Plug tops of holes to keep rain from washing solution away. This is rather important.

(5) Wait until stump seems dry before trying to burn it.

(6) Crude saltpeter is good enough.

(7) We used $\frac{3}{4}$ pound on the two-foot stump but much of the saltpeter was washed away."

THE COPPER MINING QUESTION

874. *Proposed by Carrol C. Hall, Springfield, Ill. (GQRA, No. 326)*

In one copper mine in the United States it has been found that there was *too* much copper in the mine. The metal found in this mine is *so* pure and rich that it has proven a curse instead of a blessing. In some cases this fine ore has occurred in such large quantities in this particular mine that when the miners come to it they tunnel around it instead of taking it out.

Question: What are the properties of pure copper that make for this almost unbelievable situation? (of leaving this valuable ore in the ground)?

Answer by W. G. Lawrence, Teacher of Chemistry, West High School, Cleveland (Elected to the GQRA, No. 338).

"In a recent issue of SCHOOL SCIENCE AND MATHEMATICS it was stated that at the Hecla & Calumet Copper Co. mine a large mass of copper could not be mined.

"I wrote to the company (Calumet & Hecla Consolidated Copper Co., Calumet, Mich.). They replied that you were in error. That a solid mass of pure copper was drilled with a twist drill. That the masses were not very thick (6 in. to a foot) but may weigh 15 to 20 tons. I quote—These holes are charged with a high explosive and the masses torn apart. They are then hoisted in large pieces—say about seven tons each.

This is very inexpensive mining and when present in sufficient quantity makes a cheap production.

SCIENTIFIC THINKING

868. *From a Regents Examination in Biology.*

An experiment was performed and described as follows:

Problem: Does cabbage contain vitamin D?

Method: Ten guinea pigs were placed in a pen. Four weeks later, it was noticed that four of them had rickets. Cabbage was added to the diet of all 10 guinea pigs.

Results: The four guinea pigs with rickets recovered.

Conclusion: Cabbage is a good source of vitamin D. Make *four* specific criticisms of this experiment.

Answer by Philip B. Sharpe (GQRA, No. 262), Greenwich H.S., New York.

Four specific criticisms of this experiment are that there were no steps taken to obviate the following possibilities:

1. The diet always contained some item rich in vitamin D but the six strongest pigs hogged that particular item until they could get the cabbage instead, which they preferred. Then the four weakest pigs recovered on the neglected item, not on the cabbage which perhaps contained no vitamin D, but hadn't been served long enough to bring down the strongest six with rickets.
2. The rest of the diet was changed at the same time that the cabbage was added, with or without the knowledge of the experimenter.
3. The sun had swung North or South or the food was stored in a different place at about that time, and so was bathed in vitamin D giving sunshine.
4. Perhaps the sun had swung North or South or the pen was moved so that the pigs were bathed in vitamin D creating sunshine at about the time the cabbage was added to the diet.

BOOKS AND PAMPHLETS RECEIVED

College Algebra, by Charles H. Sisam, *Professor of Mathematics, Colorado College, Colorado Springs, Colorado.* Cloth. Pages xii+395. 13.5×21.5 cm. 1940. Henry Holt and Company, 257 Fourth Avenue, New York, N. Y. Price $1.90.

Everyday Biology, by Francis D. Curtis, *Head of the Department of Science, University High School, and Professor of the Teaching of Science, University of Michigan;* Otis W. Caldwell, *Professor Emeritus, Teachers College, Columbia University, and General Secretary of the American Association for the Advancement of Science;* and Nina Henry Sherman, *Teacher of Biology, University High School, Ann Arbor, Michigan.* Cloth. Pages xi+698. 15.5×23.5 cm. 1940. Ginn and Company, 15 Ashburton Place, Boston, Mass. Price $1.92.

An Air-Conditioning Primer, by William Hull Stangle, *Forest Hills New York.* Cloth. Pages vii+236. 15Œ23 cm. 1940. McGraw-Hill Book Company, 330 West 42nd Street, New York, N. Y. Price $2.50.

Household Physics Laboratory Manual, by Madalyn Avery, *Assistant Professor of Physics, Kansas State College of Agriculture and Applied Science.* Paper. Pages vii+92. 20Œ28 cm. 1940. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price $1.50.

College Algebra, by Lewis M. Reagan, *Assistant Professor of Mathematics, Polytechnic Institute of Brooklyn;* Ellis R. Ott, *Assistant Professor of Mathematics, University of Buffalo;* and Daniel T. Sigley, *Assistant Professor of Mathematics, Kansas State College.* Cloth. Pages xviii+445. 14×21.5 cm. 1940. Farrar & Rinehart, Inc., New York, N. Y. Price $2.50.

Mathematical Clubs and Recreations, by Samuel I. Jones, Author of *Mathematical Nuts and Mathematical Wrinkles.* Formerly *Professor of Mathematics, David Lipscomb College and Assistant Secretary and Treasurer of Life and Casualty Insurance Company, Nashville, Tennessee.* Cloth. Pages xiv+236. 12.5×18.5 cm. 1940. S. I. Jones Company, 1122 Belvidere Drive, Nashville, Tenn. Price $2.75.

A New Geometry, by Theodore Herberg, *Head of Mathematics Department, Pittsfield (Mass.) High School,* and Joseph B. Orleans, *Head of Mathematics Department, George Washington High School, New York City.* Cloth. Pages vii+402. 13×20 cm. 1940. D. C. Heath and Company, 285 Columbus Avenue, Boston, Mass. Price $1.36.

Bill and the Bird Bander, by Edna H. Evans. Cloth. 228 pages. 15×22 cm. 1940. The John C. Winston Company, 1006–1016 Arch Street, Philadelphia, Pa. Price $1.50.

Study Manual for Commercial Radio Operator Examinations, by C. Radius and L. Warner, Instructors, *R. C. A. Institutes, Inc.* Paper. 55 pages. 13.5×21 cm. 1940. CRO Publications, P.O. Box 3890, Merchandise Mart, Chicago, Ill. Price 25 cents.

Elementary General Science, edited by J. M. Harrison, *Senior Science Master, Bristol Grammar School.* Book II. Cloth. 304 pages. 12×18.5 cm. 1939. Longmans, Green and Company, 114 Fifth Avenue, New York, N. Y. Price $1.40.

Odd Numbers or Arithmetic Revisited, by Herbert McKay. Cloth. 215 pages. 12.5×19.5 cm. 1940. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price $2.50.

College Algebra, by Paul R. Rider, *Professor of Mathematics, Washington University, St. Louis, Missouri.* Cloth. Pages ix+372. 13.5×21.5 cm. 1940. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price $2.00.

Calculus, by Charles K. Robbins, and Neil Little, *Purdue University, Lafayette, Indiana.* Cloth. Pages viii+398. 14.5×23 cm. 1940. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price $3.25.

Biology in the Making, by Emily Eveleth Snyder, *Science Department, Junior-Senior High School, Little Falls, New York.* Cloth. Pages xii+539. 13.5×20.5 cm. 1940. McGraw-Hill Book Company, Inc., 330 W. 42nd Street, New York, N. Y. Price $2.80.

An Introduction to Astronomy, by Robert H. Baker, *Professor of Astronomy in the University of Illinois,* Second Edition. Cloth. 315 pages. 15×23 cm. 1940. D. Van Nostrand Company, Inc., 250 Fourth Avenue, New York, N. Y. Price $3.00.

The Legal Status of Branch Banking in the United States, by Frederick A. Bradford, *Professor of Economics and Head of the Department of Finance, Lehigh University.* Paper. 33 pages. 15×23 cm. 1940.

American Economists Council for the Study of Branch Banking, Post Office Box No. 467, Grand Central Annex, New York, N. Y.

THE ROCKEFELLER FOUNDATION, A REVIEW FOR 1939, by Raymond B. Fosdick, *President of the Foundation*. Paper. 72 pages. 15×23 cm. Published by the Rockefeller Foundation, New York, N. Y.

REPRODUCTION AMONG MAMMALS, A GUIDE FOR USE WITH THE INSTRUCTIONAL SOUND FILM "REPRODUCTION AMONG MAMMALS," Prepared by Melvin Brodshaug, *Erpi Classroom Films Inc.*, and Frederick T. Howard, *Advanced School of Education, Teachers College, Columbia University*, in Collaboration with Herluf H. Strandskov, *Department of Zoology, The University of Chicago*. Paper. Pages iv+26. 13.5×20 cm. 1940. The University of Chicago Press, 5750 Ellis Avenue, Chicago, Ill. Price 15 cents.

PROCEEDINGS OF THE THIRTY-THIRD ANNUAL CONVENTION OF THE ASSOCIATION OF LIFE INSURANCE PRESIDENTS HELD IN THE WALDORF-ASTORIA, NEW YORK, N. Y., DECEMBER 14 AND 15, 1939. Paper. 282 pages. 13.5×22 cm. The Association of Life Insurance Presidents, 165 Broadway, New York.

BOOK REVIEWS

BIRDS, by Gayle Pickwell, *Professor of Zoology, at San José State College, San José, California*. Cloth. Pages xvi+252. 22.5×29 cm. 1939. McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York, N. Y. Price $3.50.

Birds by Gayle Pickwell contains interesting and worthwhile information on bird homes and home life, bird foods and feeding habits, bird travels, and bird feathers. Birds of the Far West are included with those east of the Rocky Mountains. The text is not intended as a manual for identification of birds. Chapters include: Why Know Birds, Homes of Birds, Home Life of Birds, Bird Food and How Birds Get It, Bird Feathers, Bird Travels, How Birds Are Protected from Their Enemies, Kinds of Birds, The Story of the Cowbird, and How To Know Birds.

The chapter, Home Life of Birds, contains an excellent discussion on the evolution of the nest from the very simple to the very complex as well as descriptions of the nesting territories of different species, proportionate work of parents, and feeding and growing up of the young. The section of feathers includes descriptions of natal down, flying feathers, examples of specialized feathers, distribution of feathers on birds, feather changes that occur while birds are growing up and during the different seasons in mature birds, colors and age, colors of males and females and plumages of ducks and ptarmigans. The chapter, Homes of Birds, describes the varied habitats and typical bird homes in Nebraska, Illinois, New York and California. The last chapter, How to Know Birds, contains many practical suggestions on camera equipment and methods of taking bird pictures, finding nests, devices to attract birds, bird banding, how to learn voices of birds, and effective methods of taking and keeping notes on bird excursions.

LYLE F. STEWART

A LABORATORY INTRODUCTION TO ANIMAL ECOLOGY AND TAXONOMY, by Orlando Park, *Associate Professor of Zoölogy, Northwestern University*; W. C. Allee, *Professor of Zoölogy, University of Chicago;* and V. E. Shelford, *Professor of Zoölogy, University of Illinois*. Cloth. Pages

x+472. 14×20.5 cm. 1939. The University of Chicago Press, 5750 Ellis Avenue, Chicago, Ill. Price $2.00.

This book provides a general approach to natural history from the ecological point of view by incorporating a series of laboratory exercises on the reactions of the more common field animals along with a Synoptic Key to Phyla and an excellent bibliography. This excellent text represents the work of three academic generations of teaching ecologists, Professors Shelford, Allee, and Park.

A discussion of the interrelationship of animals with their environments is taken up in the first twenty-five pages. The exercises (second division of the book) include laboratory directions which emphasize the study of the reactions of different animals; structures are studied in relation to activities and reactions. The exercises include directions for studying the following animals: pill bugs, ants, termites, beetles, aphids, toads, box turtles, protozoa, sponges, hydra, flatworms, bryozoa, blood worms, ectoparasitec oligoihaetes, leeches, plankton, clandocera, copepods. ostracods, aquatic isopods, amphipods, crayfish, mites, dragonfly and damselfly nymphs, caddisfly larvae, water beetles, snails and painted turtles. Helpful information on the outstanding characteristics, special points which aid in identification, life history, habitat, and how to collect and care for the animal is placed at the beginning of each exercise.

The Synoptic Keys (third division of the book) are excellent. The basic material for these keys was assembled by Professor Shelford. After repeated revisions in mimeographed editions Professor Allee prepared the Synoptic Key for printing in 1923. The Keys have been further modified and brought up to date by Professor Park in this book. The bibliography opens the vast literature to the student by including ancient, modern, general and specific references. This book is adapted not only for introductory college courses, but also for interested amateurs and advanced high-school students.

LYLE F. STEWART

GROWING PLANTS WITHOUT SOIL. The A.B.C. of Plant Chemiculture (Soilless Chemiculture, Water Culture, Hydroponics, Tank Farming, Sand Culture) Including Plant Growth Hormones and Their Use. By D. R. Matlin, M.A., *Professor of Plant Chemiculture, Belmont Evening High School, Los Angeles, Calif.* Second Revised Edition. Cloth. Pages 138 of text and 10 of addenda. 14×22 cm. 16 illustrations. 1940. Chemical Publishing Co. New York. $2.00.

This book appears to have been written for those who seek information of a nature not too difficult to be assimilated by non-technical people. It would be of particular use to beginners in this field, to those interested from the avocational standpoint and to those in the commercial horticultural field. There is a great deal of information in this book but the manner of giving it is very brief because of its small size. The chapter headings give an idea of the area covered: History of Soilless Gardening. Advantages of Plant Chemiculture. The Function of Plant Chemiculture. The Relation of Chemicals to Plant and Animal Life. Chemicals Needed by Plants. Germination. Formulas for Nutrient Solutions. Explanation of Use for Formula. Suggestions in Preparation and Use of Formulas and Control of Tank Culture. Construction of Tanks. Aeration. Acidity versus Alkalinity. Sand Culture. Proper Environment: Temperature, Humidity and Ventilation. How to Make Cuttings. Root Growing Substances or Hormones and Auxins. Directions for Treating Cuttings With Auxin. Budding and Grafting. The Construction and Operation of Green-

houses. Symptoms of Plant Food Deficiency and Excess in Plants. Description of Deficiency Symptoms in Apple trees. Reaction of Plants to Chemicals. Following these chapters are 70 pages of miscellaneous information on general planting, simple conversion tables, composition tables on human tissue and plant tissue, metal testing and micro chemical tests, glossary and bibliography.

A. G. ZANDER

THE PRINCIPLES OF HEREDITY, Second Edition, by Laurence H. Snyder, Sc.D., *Professor of Zoology, Ohio State University, Columbus, Ohio.* Cloth. Pages xv+452. 15×22.5 cm. 164 illustrations. 1940. D. C. Heath and Co., New York. $3.50.

The second edition of this book is a welcome addition to the field of heredity and genetics. Books published in this field from 5 to 10 years ago do not have the immensely valuable researches accomplished with the giant chromosomes of the salivary glands of the fruit fly, Drosophyla melanogaster. The terminology has been simplified and brought up to date. In spite of the fact that the subject is becoming more involved as time goes on, this book has retained fundamentally simple and direct approaches to the basic principles underlying the study of heredity. Problems illustrating the principles set forth in a chapter follow each chapter as well as a well selected short bibliography. For adequate understanding of the principles in the study of heredity well selected illustrative problems are a real necessity. This item is well planned in this book. One of the striking things about this volume is the easy readability of it. For a subject which has developed as fast as this the ease of reading is important.

A. G. ZANDER

THE PHOTISMI DE LUMINE OF MAUROLYCUS, Translated from the Latin into English by Henry Crew, *Northwestern University.* Cloth. Pages xix+134. 14.5×21.5 cm. 1940. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price $3.00.

Professor Crew has again brought help to the teachers and students of optics by translating this little book written four centuries ago. No doubt many teachers of physics have never heard of Franciscus Maurolycus. No great discoveries can be directly credited to him, but he was one of the ablest of medieval students and helped pave the way for the great discoverers of the 17th century. This book is of especial value in showing how the medieval scientists struggled to explain vision and how lenses may be used to correct defective vision; to account for the phenomena of refraction; to explain color and the rainbow. The translator's introduction giving the historical setting and a sketch of the life of Maurolycus and materially to the interest and value of the book.

G. W. W.

THE ORIGIN OF SUBMARINE CANYONS, by Douglas Johnson, *Professor of Physiography, Columbia University.* Cloth. Pages viii+126. 15×23.5 cm. 1939. Columbia University Press, 2960 Broadway, New York, N. Y. Price $2.50.

The author gives a critical review of all the hypotheses proposed to account for the origin of the great submerged canyons found on the continental shelf. Failing to find a satisfactory theory, and having found much evidence of the action of springs that have submarine outlets, the author sets up a new hypothesis. He suggests that these mighty submarine canyons, many of which surpass in magnitude the Grand Canyon of the Colorado, have been excavated by the waters of submarine springs. Due to

artesian pressure these waters may be very effective erosion agents especially where favored by other geological conditions. The author admits that it will be extremely difficult to make a decisive test of his new hypothesis, and that its greatest value may lie in the stimulus it gives to other students of this baffling question.

G. W. W.

MODERN AGRICULTURAL MATHEMATICS, a Text Book for Students of Agriculture in High Schools, Vocational Schools and Rural Schools; and a Handy Reference Book for Farmers and Other Workers in the Various Branches of Agriculture. Containing Methods of Calculation for All Types of Agricultural Problems, by Maurice Nadler, *Department of Mathematics, Agriculture Division of Newtown High School, Long Island*. Cloth. Pages x+315, 14×21 cm. Orange Judd Publishing Co., Inc., New York, New York. Price $2.00.

The rather lengthy subtitle for this book is descriptive of the general content. Included in the text are such subjects as the measurement of lengths and direction, areas and volumes, with applications to such problems as land measurement, planting of crops, measurement of lumber, and the drawing of farm plans. The second portion of the book makes detailed application to such problems as dairying, feeding of farm animals, farm power and mechanics, and the business management of farming.

At least one inconsistency was noted: With a rather careful discussion of the accuracy of measurement in the first chapter, we find answers in later chapters carrying out results far beyond anything justified by the accuracy of the data utilized.

An appendix contains some special arithmetic drills and a useful collection of tables of weights and measures including some of special value in the agricultural field.

CECIL B. READ
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MATHEMATICAL METHODS IN ENGINEERING, by Theodore v. Karman, *Director of the Guggenheim Aeronautics Laboratory, California Institute of Technology* and Maurice A. Biot, *Assistant Professor of Mechanics, Columbia University; Honorary Professor, University of Louvain*. Cloth. Pages xii+505. 15×23 cm. 1940. McGraw-Hill Book Co., Inc., 300 W. 42nd St., New York, New York. Price $4.00.

According to the authors, the book has as a primary objective the introduction of the reader to the mathematical treatment of engineering problems. The book is written for engineers rather than mathematicians and topics are introduced when need for them arises. This results in what may appear to the mathematician as a somewhat illogical order, for example, hyperbolic functions appear in the chapter on ordinary differential equations, methods of calculating the real roots of an algebraic equation (as Newton's method) occur in the chapter entitled "Small Oscillations of Conservative Systems."

As must necessarily be the case, in a book of this nature, more topics are treated than would ever be given in a single course. The treatment is such however, that various sections could be omitted without disturbing the continuity of a course. There is an ample supply of problems including applications to many engineering fields. Answers are available at the end of the book. In many cases additional references are given. An especially valuable feature is the collection entitled "Words and Phrases" which attempts to give a rigorous mathematical definition for many of the terms commonly employed by the engineer. The authors call attention to the fact that different notations are often employed for the same concept and

in some cases there is an attempt to show the equivalence of various symbols.

Although the preface indicates that calculus is the most advanced course prerequisite for an understanding of the book, the student with only the minimum requirement may have difficulty in some places. The scope of the work may be indicated by mentioning a few selected topics: Ordinary and Partial Differential Equations, Bessel Functions, Fourier Series, Operational Calculus, Calculus of Finite Differences.

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USEFUL MATHEMATICS WORKBOOK, by Mary A. Potter, *Supervisor of Mathematics, Racine, Wisconsin.* Pages 112. 1939. Ginn and Company. Boston, New York, Chicago, London, Atlanta, Dallas, Columbus, San Francisco.

This workbook supplements and enriches the material found in *Useful Mathematics*, by Dunn, Allen, Goldthwaite and Potter.

The various phases of mathematics that are covered can be ascertained by observing the table of contents. The topics are: Why we Study Mathematics, Whole Numbers, Circles, Common Fractions, Angles, Decimal Fractions, Line Segments, Triangles, Percentage, Using letters for Numbers, Equations, The Formula, Ratio and Proportion, Graphing, Scale Drawings, Measuring Perimeters, Areas and Volumes.

The book is well organized, abounds with problems and illustrative material. Teachers of mathematics who find a need for this type of workbook will welcome it as a definite answer to the question, "What can I do in order that may pupils may successfully learn mathematics?"

HYMEN D. SILVERMAN
Foreman High School
Chicago, Illinois

25-POUND CRYSTALS GROWN IN 10 DAYS

ROBERT D. POTTER

From earliest recorded times man has been using transparent solid materials to do things with light. The old-fashioned burning glass was a prized possession of early explorers, the simple magnifying glass led to the microscope and a new world of the small, telescopes expanded man's knowledge of the universe, and the spectroscope led him into the world of the atoms.

To probe the invisible ultraviolet and infrared light on the two sides of the visible spectrum, man soon learned that ordinary glasses were insufficient and turned to natural crystals like quartz, calcite and rock salt because they could still transmit radiation in these regions of wavelengths. The world was combed for bigger and bigger crystals of these materials to go into the instruments of science.

Now, however, synthetic crystals are being grown by science, according to a report prepared for the American Chemical Society by Dr. H. C. Kremers of the Harshaw Chemical Company, Cleveland.

Synthetic single rock salt crystals up to 25 pounds in weight are grown from which prisms five inches tall and with 6-inch faces can be cut. These prisms are especially good in the infrared region of the spectrum and will transmit out to 200,000 Angstroms in wavelength. The human eye can see only so far at 7,500 Ångstroms in the deep red.

Other huge synthetic crystals now being grown, says Dr. Kremers, include those of sodium nitrate, potassium bromide and lithium fluoride the latter especially useful in the ultraviolet region.

COMMENT ON "WHY TEACH MATHEMATICS"

JOHN P. HOYT, *Cornwall, N. Y.*

I agree for the most part with Mr. Jackson's article in the April SCHOOL SCIENCE AND MATHEMATICS on "Why Teach Mathematics" believing with him that mathematics above the very elementary level is not of much use to the average citizen and that it is foolish to kid one's self into trying to make it sound as if it were and consequently it should be taught to the average student only for its cultural values, etc. However, on pages 340 and 341, in his discussion of accuracy, Mr. Jackson states that pi is the ratio of two measured numbers and that pi times R^2 is therefore not an exact formula or what amounts to the same thing, that pi is not an exact number. There is probably a difference of opinion on this point but since we are not teaching mathematics for practical ends and if we take as our own personal viewpoint that of theory (which we should if most of our work is of any truth), then pi is simply the ratio of the circumference of a circle to its diameter which is proved (not approximately either) to be a constant. Since a constant (number) is exact, pi is exact. Our inability to express it exactly as a simple number is simply because it is transcondental and hence not so expressed. But it is as exact as the square root of 2.

I should also like to point out that with all the attention that has been paid in the past few years to trying to make the algebra and geometry courses fit the average student has resulted in making them misfit the better than average student or the student who really wants to learn mathematics. When a student finishes the average course (and that's what most of them get, since small schools have usually one course) in plane geometry, he knows practically nothing about proving original theorems and less than that about constructions. What one learns about plane geometry, he must learn outside the school instead of in it. Each succeeding generation of mathematics teachers will become weaker and weaker (in their elementary subjects) on this diet, which probably doesn't matter since very little mathematics is taught today even in those high schools which profess to teach it.

BRAZIL OPENS UP NEW LAND IN INTERIOR

Rapid development of agriculture and cattle raising is going on in the great interior state of Minas Gerais in Brazil, A. O. Rhoad of the U. S. Department of Agriculture told the Eighth American Scientific Congress. Although it lies within the torrid zone, the high plateau country of Minas Gerais has a temperate climate due to its altitude, and since railroad and highway development have made it more accessible, settlers have been moving in rather rapidly.

The central plateau has always been predominantly grassland, Mr. Rhoad stated. Originally, about 14% of the area was covered with open forest, but this is being rapidly cut away. Reforestation is not being consistently practised. Large numbers of eucalyptus tress have been planted, but these are intended primarily for fuel and not for soil conservation.